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Well CdV-R-37-2 Completion Report

Los Alamos
NATIONAL LABORATORY

Produced by the Risk Reduction and Environmental Stewardship Division

Cover photo shows a modified Foremost DR-24 dual-rotary drill rig. The DR-24 is one of several drill-rig types being used for drilling, well installation, and well development in support of the Los Alamos National Laboratory Hydrogeologic Workplan. The Hydrogeologic Workplan is jointly funded by the Environmental Restoration Project and Defense Programs to characterize groundwater flow beneath the 43-square-mile area of the Laboratory and to assess the impact of Laboratory activities on groundwater quality. The centerpiece of the Hydrogeologic Workplan is the installation of up to 32 deep wells in the regional aquifer.

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List of Acronyms and Abbreviations

AITH	array induction tool, version H
ASTM	American Society for Testing and Materials
BGO	bismuth germanate
bgs	below ground surface
BMP	best management practice
BV	borehole video
C/A	casing advance
CdV	Cañon de Valle
CH	cased hole
CMR	combinable magnetic resonance
CMS	corrective measures study
CNTG	compensated neutron tool, model G
DNB	dinitrobenzene
DNT	dinitrotoluene
DOE	US Department of Energy
DR	dual rotary
DTH	down the hole
ECS	elemental capture spectroscopy
ELAN	Elemental Log Analysis
EPA	US Environmental Protection Agency
ER	environmental restoration
FIP	field implementation plan

FMI	formation microimager
FSF	field support facility (part of the ER Project)
GC-MS	gas chromatography/mass spectrometry
GFAA	graphite furnace atomic absorption
GPIT	general purpose inclinometry tool
GR	gamma ray
HE	high explosives
HI	hydrogen index
HMX	1,3,5,7-tetranitro-1,3,5,7-tetrazacyclooctane (cyclotetramethylenetetranitramine)
HNGS	hostile natural gamma spectroscopy
HDPE	high-density polyethylene
HPLC	high performance liquid chromatography
HSA	hollow-stem auger
ICPES	inductively coupled plasma emission spectroscopy
ID	inside diameter
IRMS	isotope ratio mass spectrometry
LANL	Los Alamos National Laboratory
LDT	litho-density tool
LDTD	litho-density tool, version D
LOI	loss on ignition
MEQ	millequivalent
NB	nitrobenzene
NMED	New Mexico Environment Department
NTU	nephelometric turbidity unit
O/H	open hole
OD	outside diameter
PI	principal investigator
PRS	potential release site
QA	quality assurance
Qbo	Otowi Member of the Bandelier Tuff
RC	reverse circulation
RDX	1,3,5-trinitro-1,3,5-triazacyclohexane (cyclotrimethylenetrinitramine)
SBDC	Stewart Brothers Drilling Company
SSHASP	site-specific health and safety plan
SWL	static water level
TA	technical area
TD	total depth
TDS	total dissolved solids
TNB	trinitrobenzene
TNT	trinitrotoluene
UDR	universal drill rig
VOC	volatile organic compound
WCSF	waste characterization strategy form
WGII	Washington Group International, Inc.
XRD	x-ray diffraction
XRF	x-ray fluorescence

WELL CdV-R-37-2 COMPLETION REPORT

by

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ABSTRACT

The well known as Cañon de Valle R-37-2 (CdV-R-37-2) is located on the south rim of Cañon de Valle, within Technical Area 37 (TA-37) of Los Alamos National Laboratory (the Laboratory, or LANL). CdV-R-37-2 is the second of three planned wells to be completed in the vicinity of TA-16. (The first well to be completed was CdV-R-15-3.) The wells have been, or will be, constructed as part of the corrective measures study (CMS) for potential release site (PRS) 16-021(c)-99. These wells are being installed principally to investigate the extent of potential contamination in the deep perched and regional aquifers which is associated with effluents containing high explosives (HE) that discharged from TA-16 and possibly other nearby sites.

Secondary objectives for this investigation include (1) determining how fast the contamination, if confirmed to be present, is moving downgradient toward the Pajarito well field or other potential exposure points, such as Bandelier National Monument; and (2) investigating the directions of groundwater flow and the hydraulic gradients within the regional aquifer and deep perched saturated zones in the southwest part of the Laboratory. In addition, the design and construction standards for CdV-R-37-2 comply with requirements for regional aquifer characterization wells as described in the “Hydrogeologic Workplan” (LANL 1998, 59599). Thus, data collected from CdV-R-37-2 will be closely integrated with data from the regional wells drilled under that plan. The geologic, hydrologic, and geochemical data and information resulting from CdV-R- 37-2 will contribute to the understanding of the vadose zone and regional aquifer in this part of the Laboratory.

Drilling activities at CdV-R-37-2 were completed in two phases. On July 20, 2001, a pilot hole 16 in. in diameter was drilled to a depth of 40 ft below ground surface (bgs). The pilot hole was reamed to a diameter of 24 in., and 18-in.-diameter steel surface casing was cemented in place to a depth of 26 ft bgs, thus completing phase I. Phase II began with a combination of open-hole (O/H) drilling followed by 13.375-in. casing-advance (C/A) drilling to a depth of 824 ft bgs, first using a 16-in. tricone roller bit and then a down-hole hammer bit. Phase II continued with O/H drilling from 824 ft bgs to a total depth of 1664 ft bgs using 12.25-in.-diameter tricone roller and down-hole hammer bits. Cuttings samples were collected during drilling.

On July 26, 2001, and August 6 and 7, 2001, personnel from Washington Group International, Inc., and Schlumberger Integrated Water Solutions performed a suite of nine well logging runs using nine geophysical tools. Representatives from the Department of Energy (DOE), the New Mexico Environment Department (NMED), LANL, and Schlumberger reviewed the geophysical data and determined the placement of four separate screened intervals in the well. Screen 1 was installed from 914.4 to 939.5 ft in a suspected zone of perched water in the Puye Formation. Screen 2, from 1188.7 to 1213.8 ft, straddled the top of the regional aquifer in dacite lavas and interflow siltstones of the Tschicoma Formation. Screen 3, from 1353.7 to 1377.1 ft, and screen 4, from 1549.3 to 1556 ft bgs, were placed in the regional aquifer within the dacite lavas of the Tschicoma Formation. After the screens were installed, the well was developed by bailing, surging, and pumping. A Westbay MP55 sampling system was installed after well development.

The major geologic finding at CdV-R-37-2 is that thick Tschicoma Formation dacitic lavas occurred at depths where Puye Formation fanglomerates were anticipated. This discovery increases the lateral extent of thick Tschicoma lavas at depth 2 mi east from the Pajarito fault zone, into the southeastern portion of the Laboratory. Uncertainty remains about whether this dacitic mass interfingers with or abuts Cerros del Rio lavas, or Puye sediments were deposited between these two lava series that together contain the upper surface of regional saturation across most of the southern Laboratory area. Also notable at CdV-R-37-2 is the lack of perched saturation in the lower Bandelier Tuff and upper Puye fanglomerates; equivalent strata at the R-25 well host a significant zone of perched saturation. This difference suggests a limited lateral extent in this perched system.

Perched saturation was encountered in the Otowi Member, Bandelier Tuff, as predicted but not in the Puye Formation. A static water level of 1196.7 ft bgs, which was obtained when the borehole was at a depth of 1364 ft bgs, is considered to represent the regional zone of saturation. This is 30 ft deeper than predicted for the regional water table in the area. Composite head measurements at different borehole depths indicate a downward vertical gradient at CdV-R-37-2. Straddle-packer/injection testing increased the number of hydraulic conductivity values for the Tschicoma Formation on the Pajarito Plateau from one to three; values of 7.0 and 11.4 ft/d were obtained from screens 3 and 4, respectively.

Overall, waters at CdV-R-37-2 appear to be relatively unaffected by anthropogenic constituents, including drilling fluids and HE, and derived from a meteoric source with some small fraction of young water.

1.0 INTRODUCTION

This report documents the drilling, construction, development, and hydrologic testing activities of the CdV-R-37-2 characterization well, installed as part of the CMS for PRS 16-021(c)-99. CdV-R-37-2 is located within TA-37 of the Laboratory and lies approximately 200 ft north of K-Site Road at the western boundary of TA-37, on the southern rim of Cañon de Valle (Figure 1.0-1). CdV-R-37-2 is the second in a series of three wells (the first was CdV-R-15-3) installed by the Remedial Actions Focus Area and the Groundwater Investigations Focus Area of the Environmental Restoration (ER) Project. The primary objective for the well is to help determine if the HE contamination that has been detected in the perched and regional aquifers at well R-25 (located in TA-16) extends to the southeast.

Secondary objectives for this well included (1) determining how fast both water and contamination, if present, have been moving downgradient toward the Pajarito well field or toward other potential exposure points such as Bandelier National Monument; and (2) investigating the direction of groundwater flow and the hydraulic gradients within the regional and perched aquifers in the western portions of the Laboratory.

Neither CdV-R-15-3 nor CdV-R-37-2 were specifically identified in the "Hydrogeologic Workplan" (LANL 1998, 59599); however, the installation standards for both wells comply with the requirements for characterization wells in the regional aquifer as described in that plan. Data collected from CdV-R-37-2 may be used, together with data from other planned and constructed characterization wells and from other data sources, to evaluate and update the sitewide hydrogeologic conceptual model. The possibility of incorporating this well into a Laboratory-wide groundwater monitoring program will be evaluated at a later date, when the results of this characterization activity are integrated with the other groundwater investigations described in the work plan.

PART I: SITE ACTIVITIES

2.0 PRELIMINARY ACTIVITIES

Preliminary activities at CdV-R-37-2 included administrative preparation and site preparation.

2.1 Administrative Preparation

Washington Group International, Inc. (WGII), received initial incremental funding to proceed with preliminary activities for the CdV-R-37-2 well-installation project on May 31, 2001. LANL officially accepted WGII's work proposal and gave authorization to proceed with activities on July 13, 2001.

WGII prepared a site-specific health and safety plan (SSHASP), SSHASP # 0011, for well CdV-R-37-2. WGII also prepared the CdV-R-37-2 waste characterization strategy form (WCSF). LANL personnel prepared the field implementation plan (FIP) to guide field personnel in the execution of CdV-R-37-2 drilling and sampling activities. The LANL host facility was Engineering Sciences and Applications (ESA), a division of LANL. No field tenant agreement or memorandum of understanding was required.

An ER Project Readiness Review Meeting was held on June 28, 2001, to discuss all administrative documents, permits, agreements, and plans pertaining to the CdV-R-37-2 project. The Project Leader for the Groundwater Investigations Focus Area signed the readiness review checklist on July 2, 2001, giving authorization to begin fieldwork.

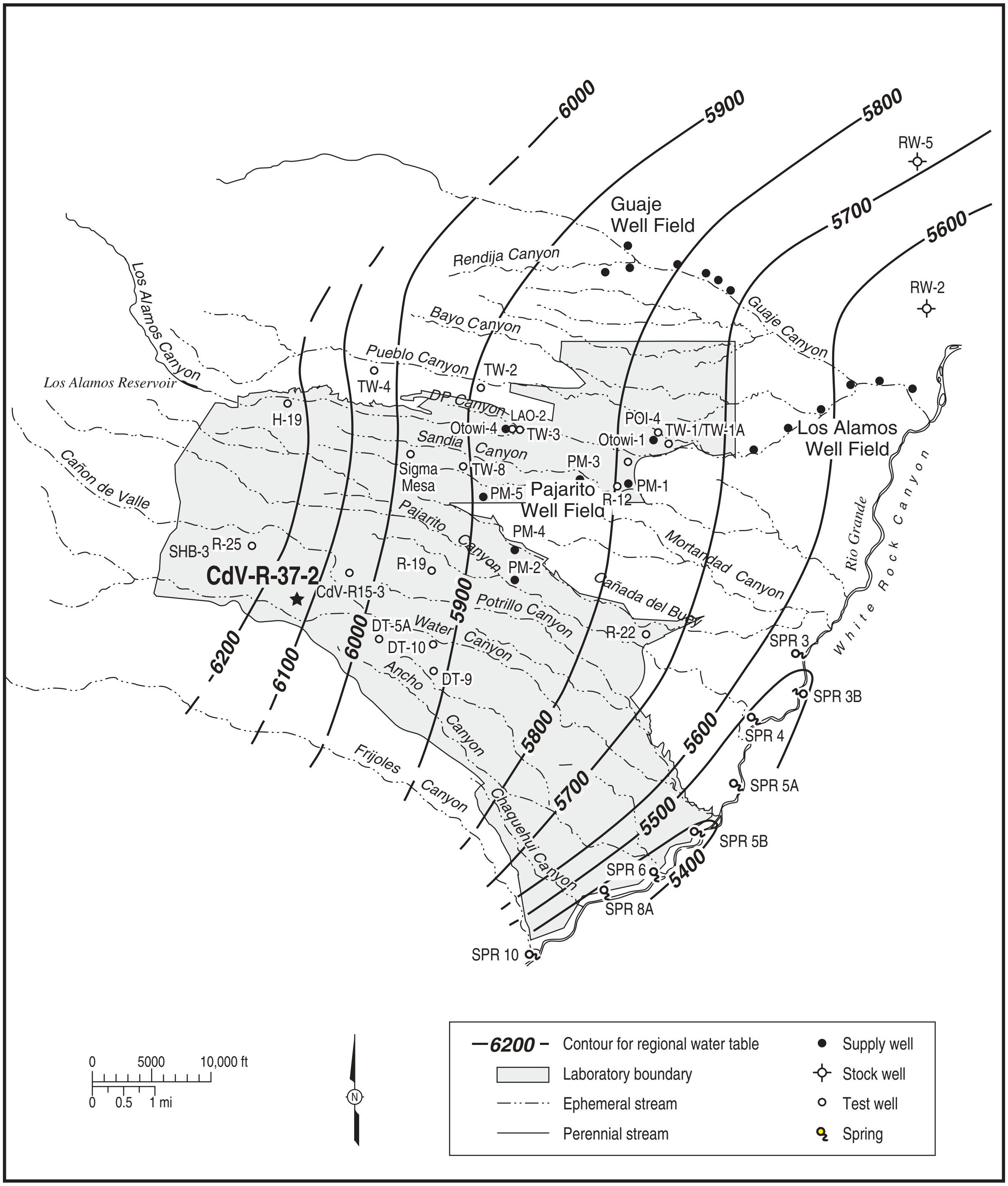


Figure 1.0-1. Location of well CdV-R-37-2

2.2 Site Preparation

Field activities commenced at the CdV-R-37-2 site on July 2, 2001. These activities included site preparation, mobilization, Phase I drilling, and installation of surface conductor casing. Site preparation involved leveling and grading the drill pad, blading an access road, removing trees, installing erosion control best management practices (BMPs), excavating a drill cuttings pit, and constructing the jack cellar. The site was fenced for silt and access control. Office trailers and portable toilets were brought to the site. Site preparation activities were completed on July 19, 2001.

3.0 DRILLING

Drilling activities at CdV-R-37-2 were completed in two phases. Sections 3.1 and 3.2 summarize Phase I and II activities, respectively. Drilling and well activity shift information is summarized below. Section 3.3 discusses drilling rates and production statistics as summarized in Table 3.3-1. A graphical representation of CdV-R-37-2 drilling and well activities through time is presented in Appendix A.

Phase I shallow drilling was performed by Stewart Brothers Drilling Company (SBDC) using a CME 750 hollow-stem auger (HSA) rig. The rig was equipped with 23-in. outside diameter (OD) augers capable of drilling into the upper part of the Bandelier Tuff for installing 18-in. steel surface casing. Phase II deep drilling was performed by Dynatec Drilling (Dynatec), Inc., using a Foremost Dual Rotary drill rig (model DR-24) with the ability to penetrate a variety of volcanic and sedimentary strata to the anticipated target depth. Air-rotary drilling was augmented with municipal water obtained from a Los Alamos County hydrant with nominal additives (EZ-MUD and QUIK-FOAM) to provide lubricity and help remove cuttings from the borehole. Both O/H and C/A drilling modes were employed, as dictated by changing geologic and drilling conditions. The DR-24 rig was also used to support well construction and development activities.

Dynatec provided three-person drilling crews, dual-wall reverse circulation (RC) drilling rods, tri-cone and down-the-hole (DTH) hammer bits of various sizes, a small front-end loader, a 1-ton flat bed truck, a 10-ton boom truck, a 3000-gal. water truck, crew vehicles, and heavy support equipment such as casing jacks.

The ER Project's Field Support Facility (FSF) provided drill casing, a dust suppression system, field support trailers (including logging and sampling trailers), high-density polyethylene (HDPE) water containment tanks, a Hermit data logger and pressure transducers, a depth-to-water meter, water sampling bailers, a diesel-powered electric generator, and water sample testing and filtering apparatus. The Laboratory's geology and geochemistry group (EES-6) provided a binocular microscope for examining drill cuttings. The water quality and hydrology group (ESH-18) provided a geophysical logging trailer.

3.1 Phase I Drilling

Phase I drilling, including site preparation and mobilization, took place from July 3 to July 19, 2001 (Table 3.1-1). The main objective of Phase I was to install surface conductor casing which would ensure stability in the upper part of the CdV-R-37-2 borehole during subsequent deep drilling. Secondarily, Phase I drilling yielded cuttings samples for characterizing the upper 35 ft of underlying Unit 4 of the Bandelier Tuff.

On July 10, 2001, SBDC mobilized the HSA rig to the site, set up over the CdV-R-37-2 well site, and drilled to a depth of 35 ft bgs using 23-in. OD augers. A section of 18-in. steel surface casing was grouted in the hole from 0 to 23 ft bgs. Grout was pumped to the ground surface at well casing and gravity-emplaced down the annulus outside the well casing. A cement jack cellar was then excavated and constructed around the surface casing. Later construction quality checks, using spirit level and plumb bob, showed that the casing was out of plumb due to shifting that had taken place during curing and setting of the cement. Consequently, both the casing and jack cellar were abandoned. Surface casing was reinstalled at an adjacent hole location during Phase II drilling.

A total of 13 shifts were required for site preparation, mobilization, and Phase I drilling. The total HSA footage drilled using 23-in. OD augers was 35 ft at an average rate of 22.1 ft/hr (Table 3.3-1). The trip-out rate for augers was 70.0 ft/hr.

Table 3.1-1
CdV-R-37-2 Drilling Shift Information

Activity	Dates	Number of Shifts*
Phase I drilling/site preparation/ rig mobilization	July 3–July 19, 2001	13
Phase II drilling	July 20–August 5, 2001	34
Geophysics/well design	August 6–August 8, 2001	5
Well installation	August 8–August 10, 2001	5
Annular backfilling	August 11–August 17, 2001	14
Well development/hydrologic testing	August 18–September 21, 2001	25
Westbay installation	September 28–October 8, 2001	11
Well completion tasks/demobilization	October 10–November 9, 2001	15
Total shifts	**July 3–November 9, 2001**	**122**

* Shift duration nominally 12 hr.

3.2 Phase II Drilling

Phase II drilling activities were conducted from July 20 to August 5, 2001 (Table 3.1-1 and Appendix A). Phase II objectives were to produce samples for geologic characterization, collect groundwater samples for contaminant analysis, and provide a deep borehole for CdV-R-37-2 well installation. During Phase II, samples of drill cuttings were collected at 5-ft intervals using a sieve placed directly below the cyclone mouth.

After determining that the Phase I surface casing did not meet specifications (see section 3.1), Dynatec repositioned the DR-24 rig at an alternate location, several ft from the first hole attempted, and advanced a pilot hole from the surface to 40 ft bgs using a 16-in. tri-cone bit. The pilot hole was then reamed to a 24-in. diameter and 18-in. surface casing was cemented in place to a depth of 26 ft bgs. A jack cellar was not constructed at the new location.

On July 21, Dynatec commenced Phase II drilling in O/H drilling mode using a 16-in. tri-cone carbide button bit, advancing the borehole in Bandelier Tuff from 40 to 794 ft bgs. Drillers noted that the bit was locking up and decided to trip it out to inspect its condition. A decision was then made to trip in 13 3/8-in. casing and to continue drilling in C/A drilling mode until a suitable depth and solid formation conditions were reached to land the casing.

On July 26, a string of retractable 13.375-in. casing was tripped in and the borehole was deepened in C/A mode from 794 to 825 ft bgs using a 12.25-in. tri-cone bit. Dynatec landed the casing string at 825 ft bgs in the Otowi Member of the Bandelier Tuff (Qbo) on July 27. An apparent water-bearing zone within the Qbo, at approximately 757 ft bgs, was measured and sampled. Drilling was resumed in O/H mode using the 12.25-in. tri-cone bit, and the borehole was advanced from 825 to 1208 ft bgs. Drilling penetrated the base of the Bandelier and entered the Puye Formation at 902 ft bgs. The stratigraphic top of a sequence of dacitic volcanic rocks was intersected at 1072 ft bgs.

On July 31, at a depth of 1208 ft bgs, drillers experienced difficulties with cleaning out the hole and with locking up of the drill bit. The 12.25-in. tri-cone bit was then tripped out and a decision was made to change to a DTH hammer bit. Dynatec tripped back in and resumed drilling in O/H mode using a 12.25-in. DTH bit from 1208 ft bgs. Drillers encountered groundwater (the regional water table) at about 1284 ft bgs within dacite volcanics. On August 1, drilling continued to a depth of 1364 ft where a water sample was collected and, 20 minutes later, the water level was measured, using an electric sounder, at 1196.7 ft. The borehole was advanced until drillers again experienced difficulties with the DTH bit. At a depth of 1404 ft, the drill string was tripped out to inspect for possible damage to the DTH bit; it was tripped back in again on August 2.

Dynatec continued to experience DTH bit malfunction. On August 3, the drill string was tripped out, the DTH bit was replaced with a 12.25-in. tri-cone bit, and drilling was resumed in O/H mode from 1404 to 1664 ft bgs. Total borehole depth was reached at 1664 ft bgs in dacitic volcanics on August 5. Rods and bit were then tripped out for the final time to permit borehole geophysical logging. The 13.375-in. casing string was eventually retracted during well construction on August 17.

3.3 Air-Rotary Drilling Production

Phase II air-rotary drilling was completed in 34 shifts (Table 3.1-1 and Appendix A). Production statistics for Phase I and II are summarized in Table 3.3-1.

Table 3.3-1
Drilling Production Statistics for Well CdV-R-37-2

Drilling Methods and Modes	Phase I HSA Drilling	Phase II Fluid-Assist, Air-Rotary RC Drilling						Total (ft)
	23-in. OD Augers	Casing, 18 in. in Diameter	O/H, 16-in. Tri-Cone Bit	C/A, 13.375-in. Casing, 12.25-in. Tri-Cone Bit	Casing, 13.375 in.	O/H, 12.25-in. Tri-Cone Bit	O/H, 12.25-in. DTH Bit	
Total footage drilled (ft)	35	N/A[a]	794	31	N/A	383	456	1699
Total footage rate (ft/hr)	22.1	NR[b]	10.8	10.4	N/A	6.4	10.6	9.5
Bandelier Tuff footage (ft)	35	N/A	794	31	N/A	77	N/A	937
Bandelier Tuff rate (ft/hr)	22.1	N/A	10.8	10.4	N/A	38.3	N/A	11.7
Puye clastics footage (ft)	N/A	N/A	N/A	N/A	N/A	170	N/A	170
Puye clastics rate (ft/hr)	N/A	N/A	N/A	N/A	N/A	5.2	N/A	5.2
Dacite footage (ft)	N/A	N/A	N/A	N/A	N/A	136	456	608
Dacite rate (ft/hr)	N/A	N/A	N/A	N/A	N/A	5.4	10.6	8.9
Trip-in footage (ft)	0	25.8	N/A	N/A	825	2229	2599	4828
Trip-in rate (ft/hr)	NR	NR	N/A	N/A	53.3	268.2	718.0	404.7
Trip-out footage (ft)	35	N/A	860	N/A	825	2872	2808	6575
Trip-out rate (ft/hr)	70	N/A	169.6	N/A	44.0	259.9	230.5	228.3

Note: All air-rotary drilling systems used 7-in. OD RC drilling rods.

[a] N/A = not applicable.

[b] NR = data not recorded.

3.3.1 O/H Drilling

With the exception of the short interval from 794 to 825 ft, the entire CdV-R-37-2 borehole was drilled using air-rotary methods in O/H mode. The total footage drilled using a 16-in. tri-cone bit was 794 ft at an average rate of 10.8 ft/hr (Table 3.3-1). The total footage drilled using a 12.25-in.tri-cone bit was 383 ft at an average rate of 6.4 ft/hr. The total O/H footage drilled using a 12.25-in. DTH bit was 456 ft at an average rate of 10.6 ft/hr.

3.3.2 C/A Drilling

Drilling was performed using a 12.25-in. tri-cone bit while advancing 13.375-in. casing with casing shoe from 794 to 825 ft. The casing itself was successfully used as a reaming tool, together with the undersized bit, to drill this 31-ft interval of soft Bandelier Tuff. The total footage drilled in C/A mode was 31 ft at an average rate of 10.4 ft/hr (Table 3.3-1).

4.0 WELL DESIGN AND CONSTRUCTION

CdV-R-37-2 was installed by the ER Project as part of implementing the addendum to the CMS plan for PRS 16-021(c) (LANL 1999, 64873). The following sections describe the well design process, which was performed jointly by the Laboratory and the subcontractor, and discuss well construction at the CdV-R-37-2 site.

4.1 Well Design

Geophysical logs, video surveys, borehole geologic samples, water-level data, field water-quality data, and driller observations were reviewed by Groundwater Investigations Focus Area personnel to plan the screen placements for well construction. The well design provided for four well screens: three in the regional zone of saturation and one across an apparent perched water zone above the water table. NMED personnel were consulted during the well design process.

On-site observations during drilling of the CdV-R-37-2 borehole, as well as geophysical log data, indicated several zones of potential saturation above the regional water table. One of these was selected to be screened. Also, several highly porous zones in the regional aquifer were identified by integrating the geophysical data generated by the combinable magnetic resonance tool, the triple lithodensity tool, the array induction tool, and the compensated neutron tool. Two of these areas were selected to be screened. The screen locations are given in Table 4.1-1. Table 4.1-1 also provides the planned and actual screen locations. The well is equipped with a Westbay monitoring and sampling system.

Table 4.1-1
Summary of CdV-R-37-2 Well Screen Information

Screen	Planned Depth (ft)	Actual Depth (ft)	Geologic/Hydrologic Setting
1	912.6–940.2	914.4–939.5	Possible saturation zone near top of the Puye Formation
2	1189.0–1214.1	1188.7–1213.8	Top of regional zone of saturation in dacitic lava
3	1348.17–1371.6	1353.7–1377.1	Regional zone of saturation in dacitic lava
4	1538.5–1545.2	1549.3–1556.0	Regional zone of saturation in dacitic lava

4.2 Well Construction

The well casing and pipe-based wire-wrap screens were constructed of 4.5-in. inside diameter (ID) (5.0-in. OD) 304 stainless steel fabricated to American Society for Testing of Materials (ASTM) A554 standards. External couplings were also type 304 stainless steel. The couplings that were used met ASTM standard

A312 and A511; the specifications of both standards exceed the tensile strength of the threaded casing ends.

The stainless-steel pipe-based screens that were used were constructed of the same diameter tubing as the blank casing risers (4.5-in. ID/5.0-in. OD). The screen openings were constructed by drilling 0.5-in.-diameter holes in 10-ft sections of well casing and welding a wire wrap (0.010-in. gap) over the perforated interval. The final OD of the screens was 5.56 in.

All stainless-steel well components were cleaned at the well site using a steam cleaner and scrub brushes. The bottom of the borehole was measured at 1656 ft bgs with tremie pipe before well casing was installed. The bottom of the well was installed at 1587.3 ft bgs. Stainless-steel centralizers were welded to the blank casing above and below each screen, and at several locations above screen 1 (Figure 4.2-1). All backfill materials were emplaced through a tremie pipe.

4.2.1 Steel Installation

Dynatec installed the well tubing from August 8, 2001, to August 10, 2001, in five drilling shifts (Table 3.1-1). Figure 4.2-1 is a graphic illustration of the final well tubing configuration and the depths below the ground surface.

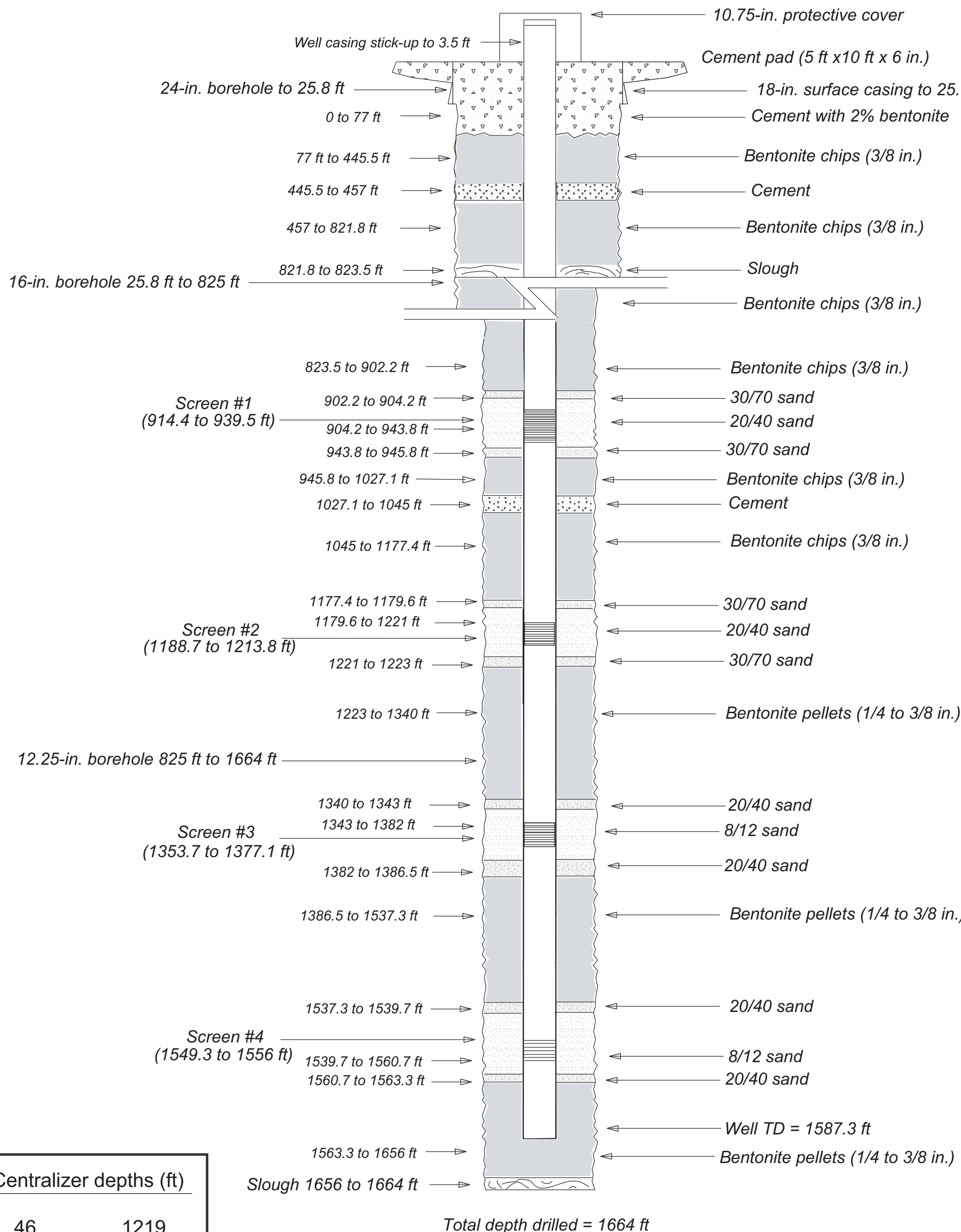
4.2.2 Annular Fill Placement

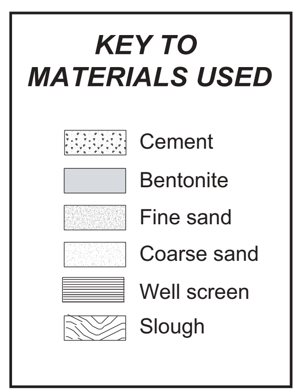
A 1.8125-in. ID steel tremie pipe was used to deliver annular materials to the specified depths (Figure 4.2-1). Dynatec emplaced annular fill from August 11 through August 18, 2001. Sands were emplaced across the screen intervals to provide porous access to formation waters and to alleviate backfill slough; the sands were tremied using municipal water as a fluid slurry. Bentonite materials were emplaced below and above the screened intervals to seal the annular space and prevent cross-communication between screens; they were delivered using EZ-MUD PLUS (polyacrylamide-polyacrylate copolymer) mixed with municipal water as a fluid slurry. Plugs of Portland cement (mixed at a ratio of 5 gal. of water per bag of cement) were placed from 445.5 to 457 ft and from 1027 to 1045 ft to provide foundations for the annular fill in the upper part of the well. Cement was also placed to provide wellhead protection of the annular space in the upper 77 ft of the borehole. Approximately 15,000 gal. of municipal water were used in placing annular material.

Table 4.2-1 summarizes the annular fill materials installed. The final configuration of the annular materials is illustrated in Figure 4.2-1.

Table 4.2-1
Annular Fill Materials Used at CdV-R-37-2

Material	Amount	Unit	Notes
20/40 sand	148	bags	Medium-grained; used to pack screened intervals
30/70 sand	12	bags	Fine-grained; used to separate screen packs from bentonite or cement from bentonite
8/12 sand	103	bags	Coarse-grained; used to plug formation fractures and matrix pores
BENSEAL bentonite	2.3	bags	Granular bentonite that produces a bentonite slurry when mixed with water
HOLEPLUG bentonite chips	1292	bags	.375-in. angular and unrefined bentonite chips
Pelplug bentonite pellets	795	buckets	Processed elliptical pellets that are .25 in. by .375 in.
Portland cement	139	bags	Mixed with municipal water at a ratio of 5 gal. of water per bag of cement





Centralizer depths (ft)	
46	1219
450	1349
912	1380
944	1547
1051	1558
1186	

Notes: The screen intervals list the footages of the pipe perforations, not the tops and bottoms of screen joints; drawing not to scale; all depths are ft bgs.

Figure 4.2-1. As-built well-completion diagram of CdV-R-37-2

5.0 WELL DEVELOPMENT

CdV-R-37-2 was developed in two phases. Preliminary development involved wire brushing, bailing, and surging. Final development was done by pumping.

First, the entire length of the production casing was scrubbed, from the top down, with a wire brush and drill rod assembly that was 14 ft, 4 in. long. The scrubbing consisted of four downstrokes and three upstrokes, each 12 ft long, throughout the length of the well. Wire brushing removed particulates that had either settled in the holes within the inner perforated portion of the pipe-based screen or were adhering to the surface of the blank production casing.

Next, the well was developed with a stainless-steel bailer that was 22 ft, 9 in. long and whose capacity was approximately 10 gal. Throughout development, field parameter measurements (pH, temperature, specific conductance, and turbidity) were taken on a sample from the first bail, for reference. After this sample was taken, bailing focused on the sump. After 100 gal. had been bailed, the water appeared to be clean. Bailing then focused on each screened interval in the saturated zone, starting at the top (screen 2). Field parameters were also measured on samples from the first and last bail from each screened interval.

After bailing was completed, the well was further developed by surging. This involved a stainless-steel surge block attached to a wireline. The surge block was dropped into the well, then retrieved. It should be noted that surging was accomplished mainly on the upstroke, as the wireline afforded no “push.” Each screen was surged in 1-ft increments. Surging action was repeated in each increment for a total of approximately 100 strokes per screen. The driller experienced difficulty when lowering the surge block past screen 4 because of particulate buildup there and in the sump; another round of bailing was conducted in order to clean screen 4 and the sump.

After some equipment problems, final development was accomplished by withdrawing water using a 7.5 hp submersible pump that was 9 ft, .75 in. long. Development by pumping involved two stages. First, the pump was set in a single position and water was discharged from screens 3 and 4 for approximately 4 hr. Next, the intake was set and the pump operated within each 1-ft interval of the open portion of screens 3 and 4. Field parameters were measured at 30-minute intervals during pumping. A summary of these measurements is given in Table 5.0-1. The plot of field parameter change during final development by pumping of screen 3 is typical (Figure 5.0-1).

Table 5.0-1
Summary of CdV-R-37-2 Pump Development Information

			Distribution of Field Parameters[a]			
Screen[b]	Elapsed Time (min)	Water Produced (gal.)	pH	Temperature (°C)	Specific Conductance (µS/cm)	Turbidity (NTU)[c]
3	1365	17,480	7.14–7.48	17.3–21.9	171.2–129.2	89.5–3.9
4	737	9,860	7.91–7.35	15.8–22.7	137.4–133.8	215–4.7

[a] Value at beginning followed by value at end; intermediate values may be higher or lower (see Figure 5.0-1).

[b] Screen 1 was above the water table; screen 2 did not make enough water to pump.

[c] NTU = nephelometric turbidity units (goal is <5 NTU); the first number is turbidity at the start of development, the second number is turbidity at completion of development.

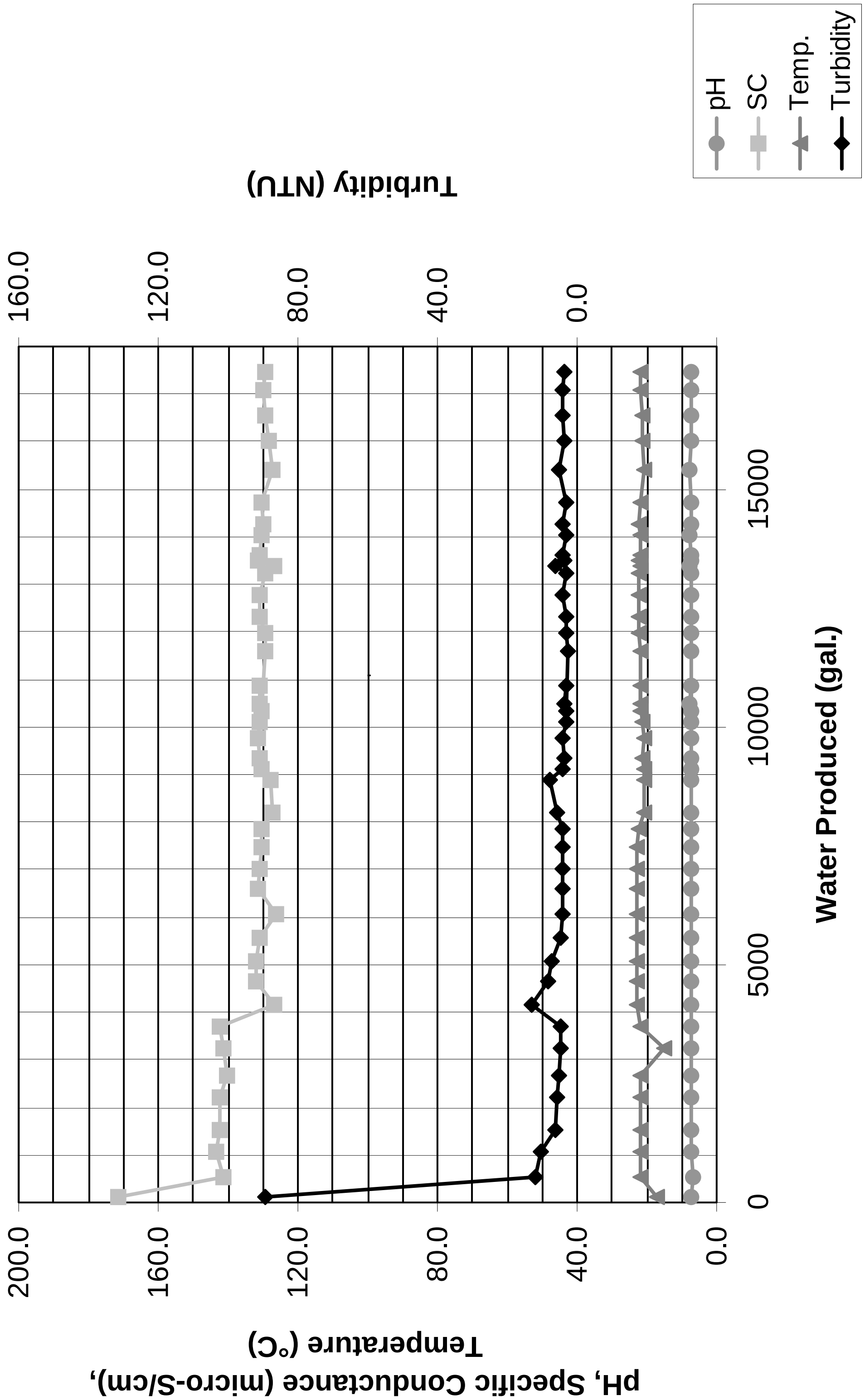


Figure 5.0-1. Results of development of CdV-R-37-2 by pumping, screen 3

6.0 SURFACE COMPLETION AND SITE RESTORATION

A concrete pad that measured 5 ft long, 10 ft wide, and 6 in. thick was poured around the wellhead. A 3-in. galvanized steel pipe was placed toward the end of the pad (opposite the well casing) for future use as a solar panel attachment. The well is protected by a 14-in. steel protective casing with locking lid. Four removable steel posts, 4 in. in diameter, were placed at each corner just outside the pad boundaries. A brass survey monument was installed in the northwest corner of the concrete pad.

The CdV-R-37-2 site area was recontoured to match the surrounding topography. Before recontouring work began, the cuttings pits were excavated, the plastic linings were removed, and the pits were refilled. In addition, the site was cleared of the slash piles created by tree removal during drill pad construction.

The hay bales and straw wattles that were part of the site BMPs remain in place as needed. The area was mulched and reseeded in spring 2002 with a LANL-provided blend of native grasses mixed with straw mulch to facilitate reintroduction of ground cover.

7.0 HYDROLOGIC TESTING

After CdV-R-37-2 had been developed and the water level had been allowed to stabilize, hydrologic testing was conducted. Testing was constrained by the multi-screen construction of the well, and neither traditional slug nor pumping tests were possible. However, a hybrid testing method was employed. More specifically, straddle-packer/injection tests were performed on two of the screened intervals (screens 3 and 4). Screen 1 (possible perched water) was not tested because it was dry. Screen 2 was not tested because it straddles the water table and the upper packer would have been in the vadose zone. Thus, injected water would have flowed into unsaturated material. Furthermore, analytical methods assume that a screen is below the water table.

The tests consisted of isolating each suitable screen with a pair of inflatable packers and then injecting municipal water at a constant rate for a short period of time. The rate of injection was monitored by means of a flow meter and stopwatch. The flow meter was installed between the Bean pump on the universal drill rig (UDR) and the hose used to inject the water down the drill rod attached to the packer assembly. The pre-test water level was determined using an electric probe. The water level during testing was monitored with a transducer placed within the water-filled rod leading to the packer assembly. Observations were recorded on a data logger. Preliminary results are given in section 12.2.2.

8.0 WESTBAY INSTRUMENTATION

Following well development and hydrogeologic testing, the Westbay MP55 System for groundwater monitoring was installed in the steel-cased well. Model 2523 MOSDAX sampling probe equipment will be used to collect groundwater samples from the completed well.

An MP casing installation log, which specifies the location of each component in the borehole, was prepared in the field by Westbay, in consultation with WGII, based on the well's as-built diagram. A borehole video log taken by WGII inside the steel well casing on 09/20/01 was also reviewed. The steel well arrangement included a nominal 20-ft length of blank stainless-steel casing above and below each screen section. The pair of MP packers immediately above, and the single packer immediately below, each screened interval were positioned in these continuous 20-ft lengths of casing. The final version of the MP casing installation log, dated September 24, 2001, was approved by the Laboratory prior to installation of the well. The MP casing installation log, as approved, was used as the installation guide in the field.

An MP measurement port coupling and associated magnetic location collar were included in each monitoring zone to allow for the measurement of fluid pressures and the collection of fluid samples. A pumping port coupling was also included in each of the screened monitoring zones to allow for purging, sampling, and hydraulic conductivity testing. An additional measurement port coupling was included below the pumping ports for monitoring hydraulic tests. Measurement port couplings were included in quality assurance (QA) zones below each of the MP55 packers to permit checking the squeeze/relief functions of the MP55 packer equipment.

The MP casing components were set out in sequence, according to the MP casing installation log, on racks near the borehole. As an aid to confirming the proper sequence of components, each casing length was numbered in order, beginning with the lowermost. The appropriate MP system coupling was attached to each piece of MP casing. Magnetic location collars were attached 2.5 ft below the measurement ports in each of the primary monitoring zones and 7.5 ft below MP coupling number 179 near the top of the well, as well as below MP coupling numbers 147 and 117, located beneath the first two packers from ground surface.

The length of each MP casing section was measured with a steel tape to confirm nominal lengths.The data were entered on the field copy of the MP casing installation log. Each casing component was visually inspected, and serial numbers for each packer, measurement port coupling, and pumping port coupling were also recorded on the field copy of the MP casing installation log.

The MP casing components were lowered into the well, in sequence, with a Smeal work-over rig provided by LANL. Each casing joint was tested with a minimum internal pressure of 300 psi for 1 minute to confirm hydraulic seals. Distilled water, supplied by WGII, was used for the joint tests. Each successful joint test and the placement of each casing component were recorded on the field copy of the MP casing installation log. Geotextile filters were installed on each of the QA zone measurement ports. The suspended weight of the MP casing components was monitored during lowering to confirm that operating limits of the MP system casing components were not exceeded. Lowering of the MP casing to the target position was successfully completed on September 30, 2001.

After the casing was lowered into the borehole, the water level inside the MP casing was left at a depth of approximately 1281 ft below ground level to confirm the hydraulic integrity of the casing. The open-hole water level was approximately 1200 ft below ground level. With this differential pressure acting on the MP casing string, the water level inside the MP casing was stable over a measurement period of 10 minutes, as measured with a MOSDAX sampler probe transducer inside the MP casing. The data from the hydraulic integrity test are shown on page 3 of the MP casing installation log (Appendix D). The test indicated that the MP casing was watertight.

After the components were lowered into the well and the hydraulic integrity of the MP casing had been confirmed, the MP casing string was positioned as shown on the MP casing installation log (Appendix D). The datum for the borehole was ground level. The MP casing string was supported with the top of MP coupling no. 179 at a depth of 1.4 ft above the top of the 4.5-in. ID well casing. Over the period from October 1 to October 8, 2001, the MP packers were inflated using distilled water supplied by WGII. During this period, packer inflation was interrupted for two days (October 3 to 4, 2001) due to jamming of the packer inflation tool while attempting to locate packer no. 13 (second from bottom). The problem was resolved without damage to the tool or multi-port system, and packer inflation resumed on October 5, 2001. The packers were inflated in sequence beginning with the lowermost. All of the packers were inflated successfully and QA tests showed that all the packer valves were closed and sealed.

After lowering and final positioning of the MP casing, the tensile load at the top of the MP casing was 2200 lb. Westbay's standard procedure for destressing the MP casing was carried out. The MP casing was lowered after inflation of packers no. MP02, MP33, and MP54 to distribute some of the weight of the MP casing to the packers. The final load at the top of the MP casing was 400 lb. During the destressing, the top of coupling no. 180 was lowered from the starting point of 5.1 ft above ground level to a final depth of 3.7 ft.

After destressing and lowering the MP casing, a clamp was placed at the top of the 4.5-in. ID well casing, and a stainless-steel MP55 top coupling was installed. A sketch of the as-built top of the MP casing and the final positions of the MP well components are shown on the summary casing log (Appendix D).

On October 1, a set of fluid pressure measurements was taken at each measurement port as a QA check on port performance before the packers were inflated. The MP casing was not at the final installed position at the time of these readings. All measurements were normal, indicating normal port performance. A plot of the piezometric levels in all zones, including QA zones, based on the October 1 pre-inflation pressure measurements, is shown on Figure 1 in Appendix D. The MOSDAX data report for the pre-inflation pressure profile is also part of Figure 1 in Appendix D. After packer inflation was completed, fluid pressures were measured at each measurement port. The fluid pressure profile measurements were taken on October 8, 2001. At that time, the in-situ formation pressures may not have recovered from the pre-installation and installation activities. Longer term monitoring may be required to establish representative fluid pressures.

A plot of the piezometric levels in all zones, including QA zones, based on the October 8 pressure measurements, was reviewed to confirm proper operation of the measurement ports and as a check on the presence of annulus seals between adjacent monitoring zones (see Figure 2 in Appendix D). All measurement ports operated normally. Each of the packers below the open-hole water level was supporting a differential hydraulic pressure, indicating effective performance.

9.0 GEODETIC SURVEY OF COMPLETED WELL

The location of CdV-R-37-2 was determined by geodetic survey on December 12, 2001, using a Wild/Leica TC 1000 total station. Controls for the survey were Stations 1101 and 3701 from the 1992 Laboratory-wide control network. Field measurements were reduced using LisCad Plus 5.0 surveying software.

The survey located the brass cap monument in the northwest corner of the concrete pad at the well and measured elevations to the top of the exterior well casing, the top of the uppermost Westbay casing coupling, and the top of the Westbay aluminum plate (Table 9.0-1). Horizontal well coordinates are New Mexico State Plane Grid Coordinates, Central Zone (North American Datum, 1983 [NAD 83]) and are expressed in feet. Elevation is expressed in feet above mean sea level relative to the National Geodetic Vertical Datum of 1929.

Table 9.0-1
Geodetic Data for Well CdV-R-37-2

Description	Easting	Northing	Elevation
Top of Westbay plate	1619216.112	1759321.246	7333.3
Top of Westbay casing	1619216.185	1759321.228	7333.7
Top of steel casing	1619216.685	1759320.789	7334.1
Brass monument	1619218.959	1759327.283	7330.6

PART II: ANALYSES AND INTERPRETATIONS

10.0 GEOLOGY

The location of CdV-R-37-2 is shown in Figure 1.0-1 and, relative to other drill holes at the LANL site, in Figure 10.0-1. Figure 10.0-1 shows drill-hole correlation lines that include CdV-R-37-2 and parallel the southern boundary of the Laboratory, from SHB-3 to R-31, or pass from CdV-R-37-2 north to TW-4. The correlations between drill holes are discussed later in this report (section 10.1.6). The geologic units encountered in CdV-R-37-2 consist of the following, in descending order:

- Units Qbt 4 through Qbt 1g of the Tshirege Member of the Bandelier Tuff (basal Tsankawi Pumice Bed not evident),
- tephras and volcaniclastic sediments of the Cerro Toledo interval,
- the Otowi Member of the Bandelier Tuff, including the basal Guaje Pumice Bed,
- the Puye Formation fanglomerate facies, and
- lavas of the Tschicoma Formation.

Descriptions of geologic units are based on examination of cuttings and thin sections, on geochemical data acquired by x-ray fluorescence (XRF), on mineralogic data acquired by x-ray diffraction (XRD), on geophysical logs, and on drilling information. Depths and elevations of the contacts between these units are shown in Figure 10.0-2, with a comparison to the predicted stratigraphy based on the 3-D geologic model available at the time drilling began. The most notable difference between the predicted and as-drilled stratigraphy is the great thickness of Tschicoma Formation lavas where Puye Formation fanglomerates were predicted.

A summary of unit characteristics is given in the following sections, and a detailed lithologic log is provided in Appendix C. Composite logs from Schlumberger were used, along with analysis of cuttings, to define the stratigraphy at CdV-R-37-2 and were supplemented by video logs, an induction log, and natural gamma logs collected using Laboratory tools. No core was collected during the drilling of CdV-R-37-2, so all studies of borehole materials were based on cuttings. Cuttings were collected by reverse circulation, thereby minimizing the admixture of materials from upper portions of the borehole (see section 3).

Representative samples of the upper Tshirege Member, Puye Formation, and Tschicoma Formation were selected for chemical (XRF) and mineralogic (XRD) analyses. Samples were selected to represent most of the horizons at which Westbay sampling screens were installed; in addition, samples were selected for chemical or mineralogic analysis from areas where characterization for stratigraphic correlation was deemed necessary. The results of XRF analyses are shown in Table 10.0-1; the results of XRD analyses are shown in Table 10.0-2. To aid stratigraphic analysis, thin sections of samples were also prepared; the results of thin-section petrography are summarized in Appendix E. The chemical, mineralogic, and petrographic data are cited throughout the following descriptions of geologic units at CdV-R-37-2.

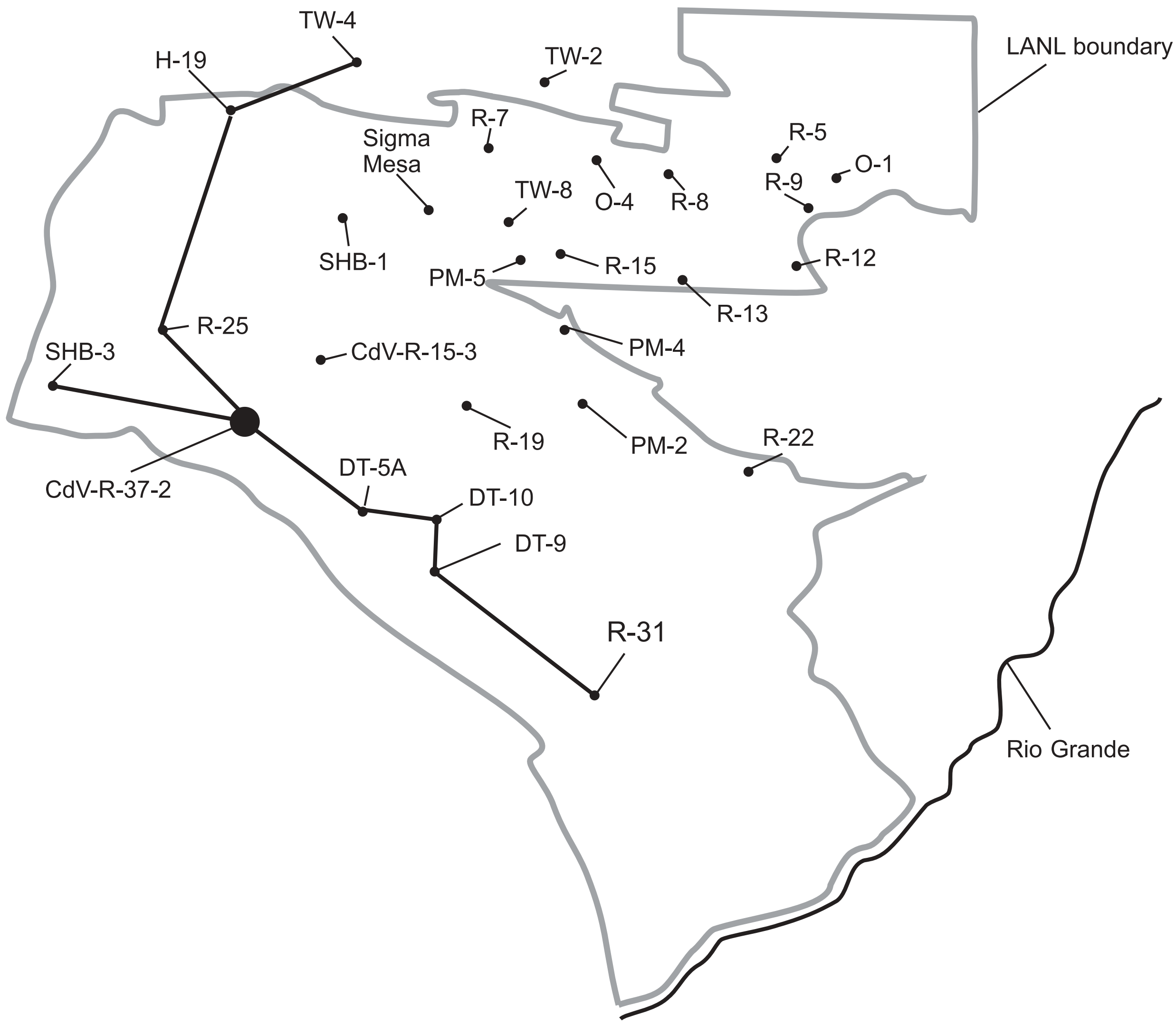


Figure 10.0-1. Location of well CdV-R-37-2 and lines of section for Figure 10.1-2 and Figure 10.1-3; locations of other drill holes, the Laboratory boundary, and the Rio Grande are indicated for reference

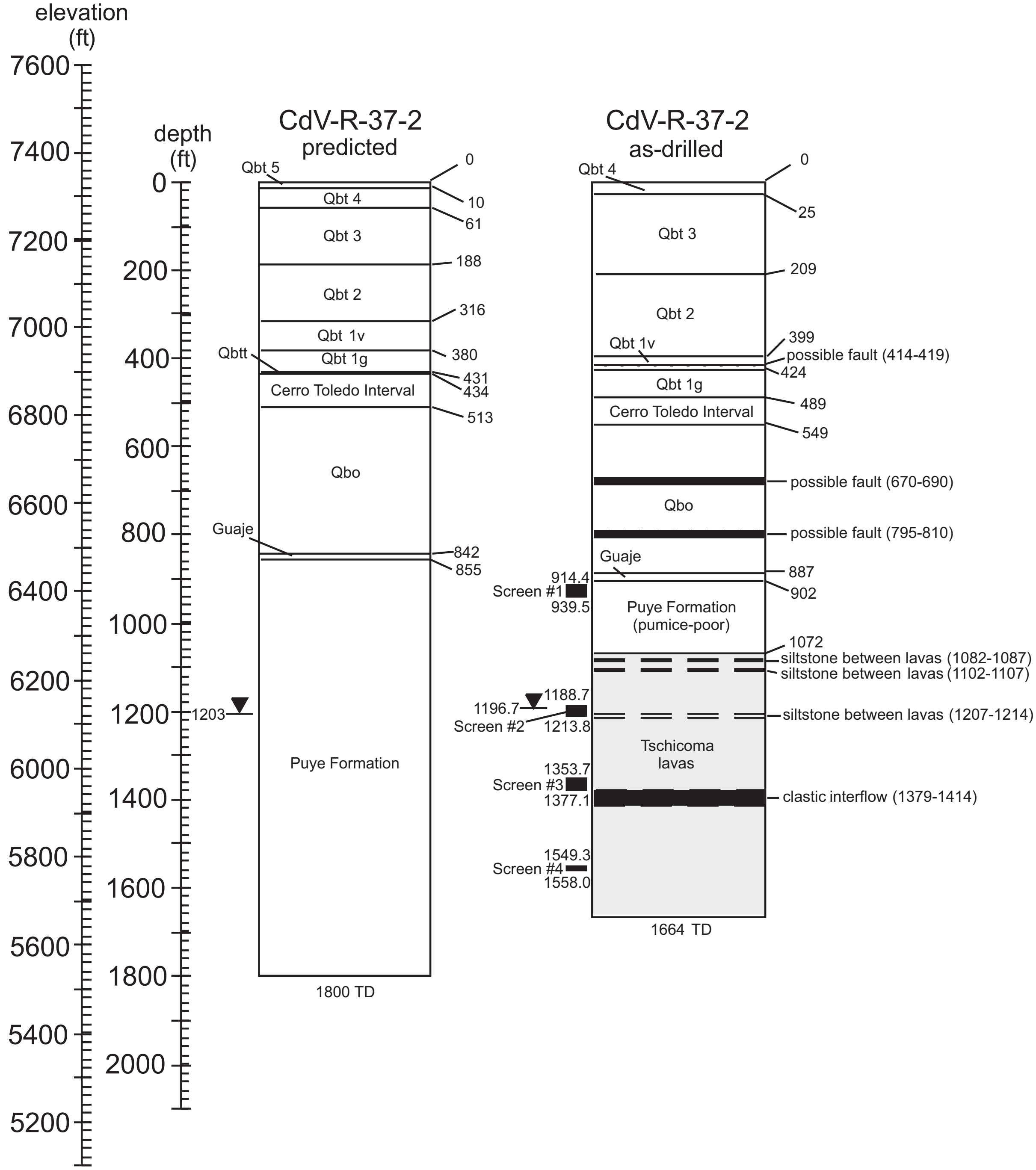


Figure 10.0-2. Stratigraphy predicted at CdV-R-37-2 based on the 1999 3-D geologic model, compared with the stratigraphy interpreted from cuttings, geophysical logs, and video logs

Table 10.0-1
XRF Analyses for CdV-R-37-2

Sample and Depth[a]	(1) CdV-R-37 907–912	(2) CdV-R-37 967–972	(3) CdV-R-37 1062–1067	(4) CdV-R-37 1062–1067	(5) CdV-R-37 1072–1077	(6) CdV-R-37 1207–1209	(7) CdV-R-37 1389–1394	(8) CdV-R-37 1654–1659
Lithology	Puye	Puye	Puye Dacite Clasts	Puye Siltstone	Tschicoma	Siltstone	Tschicoma Clasts	Tschicoma
Size Analyzed	2–4 mm	2–4 mm	Hand-picked	Hand-picked	Hand-picked	Hand-picked	Hand-picked	Hand-picked
Silicon dioxide (SiO_2) %	67.3	67.8	66.1	69.3	66.4	67.5	65.8	64.9
Titanium dioxide (TiO_2) %	0.53	0.47	0.56	0.79	0.54	0.73	0.55	0.62
Aluminum oxide (Al_2O_3) %	14.91	14.69	14.92	14.02	14.94	14.53	15.11	15.92
Ferrous oxide (FeO) %	1.31	1.11	1.38	0.29	0.20	1.83	1.91	1.50
Ferric oxide (Fe_2O_3) %	2.61	2.37	2.74	3.92	3.98	2.59	2.21	2.88
Manganese oxide (MnO) %	0.06	0.06	0.07	0.07	0.06	0.07	0.07	0.08
Magnesium oxide (MgO) %	1.56	1.41	1.89	1.13	1.97	1.65	2.12	2.07
Calcium oxide (CaO) %	3.24	2.99	3.55	1.81	3.62	1.62	3.71	4.17
Sodium oxide (Na_2O) %	3.91	3.96	3.80	1.91	3.92	1.52	3.77	4.04
Potassium oxide (K_2O) %	3.16	3.40	3.02	2.31	2.93	2.38	2.95	2.55
Phosphorus pentoxide (P_2O_5) %	0.20	0.17	0.21	0.06	0.20	0.07	0.20	0.24
LOI[b] %	0.27	0.45	0.82	3.54	0.12	4.42	0.70	0.24
Total %	**99.1**	**98.9**	**99.1**	**99.2**	**98.9**	**98.9**	**99.1**	**99.2**
Vanadium (ppm)	57	58	61	61	60	60	63	75
Chromium (ppm)	24	26	37	53	34	43	39	26
Nickel (ppm)	14	15	18	15	24	16	22	<12
Zinc (ppm)	63	61	61	73	66	79	57	69
Rubidium (ppm)	57	71	45	93	49	107	49	40
Strontium (ppm)	478	440	499	310	500	261	505	611
Yttrium (ppm)	14	18	26	28	25	31	16	14
Zirconium (ppm)	172	177	183	423	174	353	177	180
Niobium (ppm)	21	16	<8	31	21	25	17	19
Barium (ppm)	1322	1203	1359	777	1381	760	1307	1322

[a] Number ranges indicate depth ranges of cuttings in ft.

[b] LOI = loss on ignition.

Notes: Values reported in percent or parts per million by weight. Analytical errors (2σ) are silicon dioxide, 0.7; titanium dioxide, 0.01, aluminum oxide, 0.2; iron oxide, 0.06; manganese oxide, 0.01; magnesium oxide, 0.08; calcium oxide, 0.1; sodium oxide, 0.1; potassium oxide, 0.05; phosphorus pentoxide, 0.01; vanadium, 10; chromium, 8; nickel, 10; zinc, 12; rubidium, 5; strontium, 25; yttrium, 6; zirconium, 30; niobium, 7; and barium, 50.

Table 10.0-2
XRD Analyses of Sediments from CdV-R-37-2 (Weight %)

	Sample	Smectite	Kaolinite*	Clinoptilolite	Tridymite	Cristobalite	Quartz	Alkali Feldspar	Plagioclase	Glass	Hematite	Magnetite	Biotite	Hornblende	Total
(1)	Cdv-R-37-2, 907–912 (Puye)	—	—	—	15.6	7.2	0.6	19.3	46.0	5.0	0.6	3.2	1.1	—	98.6
(2)	Cdv-R-37-2, 967–972 (Puye)	—	—	—	12.3	8.4	0.5	17.8	43.6	12.0	0.7	2.8	1.8	—	99.8
(3)	Cdv-R-37-2, 1062–1067 (dacite clasts)	—	—	—	2.0	9.5	0.1	8.5	41.3	33.7	0.7	3.3	0.5	0.6	100.2
(4)	Cdv-R-37-2, 1062–1067 (siltstone)	35.0	0.5	0.9	0.9	1.6	30.3	6.5	24.6	—	0.4	0.6	1.2	0.3	102.8
(5)	Cdv-R-37-2, 1207–1209 (siltstone)	43.5	0.6	1.5	0.9	1.9	27.5	6.5	28.2	—	0.4	—	0.8	0.1	101.8

* Kaolinite and/or halloysite.

10.1 Stratigraphy at CdV-R-37-2

10.1.1 Tshirege Member of the Bandelier Tuff

The Pleistocene Tshirege Member of the Bandelier Tuff at CdV-R-37-2 consists of multiple cooling units, designated downsection as units Qbt 4, 3, 2, 1v, and 1g. Nomenclature and definition of these units follows the usage of Broxton and Reneau (1995, 49726). Subunits of the Bandelier Tuff and the Cerro Toledo deposits have electrical and natural gamma-ray emission properties that aid in visualizing stratigraphic variability; this visualization is provided in Figure 10.1-1.

10.1.1.1 Qbt 4 (0- to 25-ft depth)

A poorly welded sequence of Qbt 4 of the Tshirege Member was encountered at CdV-R-37-2. At this site, Qbt 4 consists of vitric ash-flow tuff. Compared to the underlying units of the Tshirege Member, Qbt 4 is poorer in silica and richer in titanium, iron, and barium (Broxton et al. 1995, 54709). Cuttings from this interval are yellow-orange to yellow in color, vitric, and variably welded, with a transition from poorly welded to nonwelded occurring at about 20- to 25-ft depth. Although the contact with underlying unit Qbt 3 is placed at 25-ft depth, some uncertainty in assignment of the nonwelded interval from 25- to 49-ft depth may allow this contact to be as deep as 49 ft. Pumices in Qbt 4 to the depth of 25 ft contain abundant crystal clots that consist of plagioclase and sanidine feldspar clusters centered on splays of clinopyroxene with less common occurrences of biotite and oxide minerals.

10.1.1.2 Qbt 3 (25- to 209-ft depth)

Unit Qbt 3 of the Tshirege Member is placed between the depths of 25 ft and 209 ft in CdV-R-37-2. No cuttings were returned from the interval of 35–40 ft. Cuttings at 40–44 ft contained abundant rounded Precambrian clasts, but these represent contamination by gravel from the drilling pad which sloughed into the hole as the surface casing was emplaced.

Qbt 3 consists of massive, poorly consolidated, devitrified, nonwelded to moderately-welded, ash-flow tuff. Compositionally, this unit is more typical of the lower Tshirege ash flows, which are distinctly less mafic than Qbt 4. Cuttings from this interval contain abundant bipyramidal quartz and sanidine. Borehole geophysical data collected across the contact between Qbt 3 and Qbt 2 indicate a modest rise in natural gamma signal and a relatively conductive horizon in the lower ~20 ft of Qbt 3 (Figure 10.1-1). The enhanced conductivity at the base of Qbt 3 may reflect retention of drilling fluids in the porous, nonwelded lower portion of this unit.

10.1.1.3 Qbt 2 (209- to 399-ft depth)

Unit Qbt 2 of the Tshirege Member was encountered between depths of 209 ft and 399 ft. This unit consists of massive, devitrified, ash-flow tuff that is strongly welded in the upper portion (~209- to 329-ft depth) and poorly welded to nonwelded in the lower portion (~329- to 399-ft depth). Although completely vapor-phase altered, in most locales unit Qbt 2 differs from the upper parts of the Tshirege by its silica-phase assemblage dominated by tridymite and quartz, lacking cristobalite that is common in the overlying zones of vapor-phase alteration (Broxton et al. 1995, 54709).

The contact between unit Qbt 2 and Qbt 1v is difficult to distinguish based on analysis of cuttings (Broxton et al. 1995, 54709). There is little difference in welding, color, pumice size and abundance, or phenocryst content across this contact. Nevertheless, there is an ash-flow contact between these units, locally marked by surge deposits or a prominent horizontal parting that is visible in outcrop but not cuttings. The very high conductivity at the 399-ft depth (Figure 10.1-1) has been interpreted as a concentration of drilling fluids within the discontinuity between Qbt 2 and Qbt 1v at CdV-R-37-2.

10.1.1.4 Qbt 1v (399- to 424-ft depth)

Unit Qbt 1v of the Tshirege Member was encountered between depths of 399 ft and 424 ft. The lower contact of Qbt 1v is marked by the appearance of glass. Unit Qbt 1v consists of massive, poorly consolidated, devitrified, nonwelded, ash-flow tuff. The use of *v* in the unit symbol refers to the extensive vapor-phase alteration in the upper part of Qbt 1. This vapor-phase alteration contrasts with the lower part, Qbt 1g, in which primary glass is largely preserved, with little vapor-phase alteration. The natural gamma log (Figure 10.1-1) shows no difference between Qbt 1v and Qbt 1g. This similarity is to be expected because of the uniform composition of these units, which are chemically identical and differ only in the crystallization of glass in Qbt 1v. The induction log, however, indicates that the high conductivity at the Qbt 2/Qbt 1v contact (see above) persists through most of the devitrified but evidently porous matrix of Qbt 1v. This high conductivity, which is attributable to the retention of drilling water, diminishes to more typical values of ~40–50 mS/meter in Qbt 1g. It is not known if this is a result of poorer water retention in Qbt 1v or merely the tailing off of saturation accumulated at the Qbt 2/Qbt 1v contact, with no significant difference in water-retention capability between Qbt 1v and Qbt 1g.

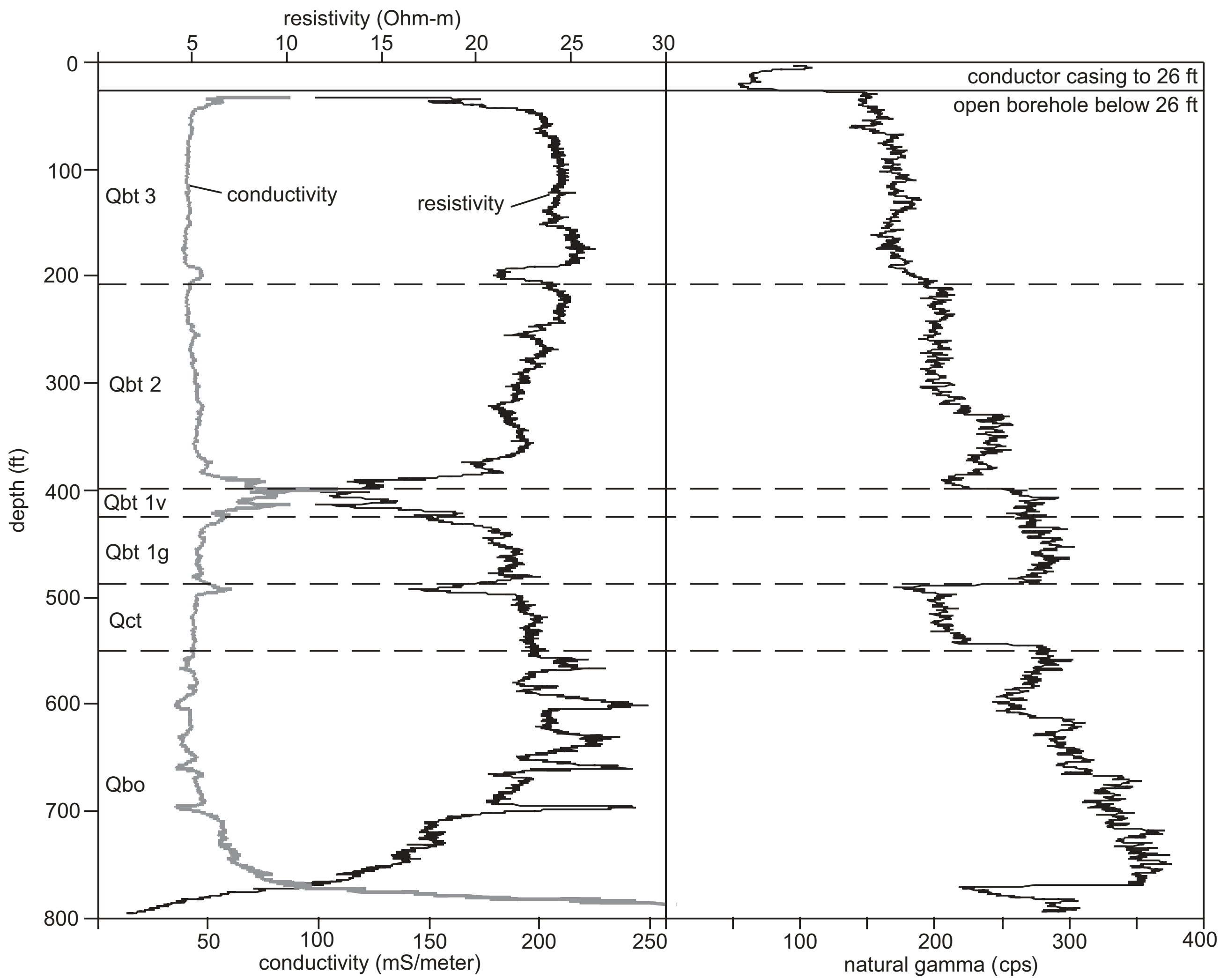


Figure 10.1-1. Induction log and natural gamma log for the upper 800 ft of CdV-R-37-2

An occurrence of tuff fragments cemented by very dark-brown detritus-laden clay at 414- to 419-ft depth may indicate the presence of a fault. Exceptionally dark clays have been observed in core elsewhere where faults are penetrated higher in the tuff section at TA-16 (Gardner et al. 2001, 70106.1). X-ray diffraction analysis of clay separated from this sample shows it to be poorly crystalline smectite with a broad 001 diffraction peak and traces of relict mica, typical of clays that originate in soils on mesa surfaces of the Pajarito Plateau (Vaniman et al. 2002, 73616). Geochemical data could be obtained to help determine if these clays were derived from the surface, to test whether translocation of clay particles to considerable depth has occurred in fractures of faults of the unsaturated Bandelier Tuff.

10.1.1.5 Qbt 1g (424- to 489-ft depth)

Unit Qbt 1g of the Tshirege Member was encountered between depths of 424 and 489 ft. This unit consists of massive, poorly consolidated, vitric, nonwelded, ash-flow tuff. The Tsankawi Pumice Bed may be present in the interval from 484 to 489 ft (see Appendix C); thin occurrences of this pumiceous unit are difficult to detect in cuttings.

10.1.2 Tephras and Volcaniclastic Sediments of the Cerro Toledo Interval (489- to 549-ft depth)

The Pleistocene Cerro Toledo interval (Qct) extends from 489 to 549 ft in CdV-R-37-2 (Appendix C). The thickness of this unit, 60 ft, is slightly less than the thickness predicted by the 3-D geologic model at the time of drilling (79 ft; Figure 10.0-2) but much less than the thickness of Cerro Toledo sediments logged at drill hole CdV-R-15-3 to the northeast (220 ft thick). As in most other drill holes, the Cerro Toledo deposits have a significantly lower natural gamma signal than the overlying Qbt 1v/Qbt 1g deposits or the underlying Qbo ash flows (Figure 10.1-1). The uppermost part of the Cerro Toledo (~489- to 499-ft depth) in CdV-R-37-2 is marked by a zone of relatively high conductivity and low natural gamma signal (Figure 10.1-1). The higher conductivity at the top may reflect sandy tuffaceous sediments that retain more drilling fluid than the more poorly sorted sediments deeper in the Cerro Toledo interval.

10.1.3 Otowi Member of the Bandelier Tuff; Ash Flows (Qbo; 549- to 887-ft depth) and Guaje Pumice Bed (Qbog; 887- to 902-ft depth)

Tuffs of the Pleistocene Otowi Member, including ash flows (Qbo) and the basal Guaje Pumice Bed (Qbog), were encountered between depths of 549 and 902 ft. At CdV-R-37-2, the ash flows of the Otowi Member consist of massive, poorly consolidated, vitric, nonwelded tuff. The Guaje Pumice Bed occurs beneath the ash flows from a depth of 887 ft to 902 ft.

Although the cuttings from the ash flows are relatively homogeneous, the induction log shows several intervals in which the conductivity drops and there are several discontinuities in the natural gamma signal (Figure 10.1-1). In general, the electrical and gamma variations in the borehole geophysical logs are not correlated. The discontinuities in the natural gamma log are relatively few (two or perhaps three, at ~610-, 670-, and 715-ft depths) and may be associated with contacts between ash flow units of slightly variable composition. There are at least five depths at which the conductivity drops (and resistivity rises); these inflections are relatively sharp and generally return to a smooth continuum. The excursions in the induction log may reflect large lithic clasts or lithic swarms of low conductivity; however, this assumption would be difficult to confirm by examination of cuttings. Tool noise may also be a factor, but such intra-unit conductivity/resistivity excursions are not observed higher in the section, indicating that these signal spikes are specific to the Otowi Member. Note that the conductivity log (Figure 10.1-1) rises sharply below ~725 ft and goes off the scale above 800 ft. This is due to drilling water that accumulated within the lower part of the borehole when the log was acquired.

Evidence of possible fault-related clays was observed in cuttings from two depth ranges within the Otowi ash flows (the 670- to 690-ft depth and the 795- to 810-ft depth). As with the clays of possible fault association in Tshirege unit Qbt 1v (section 10.1.1.4), these clays have X-ray diffraction patterns that are typical of poorly crystalline soil smectites and may indicate particulate transport from the surface. If so, the occurrence of such clays to depths of ~800 ft would provide evidence of the deepest range of vadose zone clay-particle transport yet observed beneath the Laboratory. However, it is possible that clays could have been introduced from soils developed on top of the Otowi ash flows prior to Cerro Toledo deposition, with transport depths of only ~140 to 260 ft.

The Guaje Pumice Bed (Qbog) is ~15-ft thick at CdV-R-37-2. This interval is marked by an abundance of white pumice and dacitic to rhyodacitic lithic fragments (Appendix C). The interval is not marked by any increase in natural and spectral gamma signals, in contrast with the strong increase in gamma signal across Qbog in drill holes such as R-31 (Vaniman et al. 2002, 72615). In fact, at CdV-R-37-2, the lower part of Qbog (the 891- to 902-ft depth) has a diminished total gamma signal relative to the overlying Qbo ash flow (see the CD attached to this report). The most reliable marker of Qbog in CdV-R-37-2, as in most other drill holes, is a distinctive rise in the medium-pore to large-pore water content recorded in the combinable magnetic resonance (CMR) borehole log. This rise in free water abundance occurs within the 887- to 902-ft depth range in CdV-R-37-2 (see the CD attached to this report).

10.1.4 Puye Formation Fanglomerate (Tpf; 902- to 1072-ft depth)

A fanglomerate sequence of the Puye Formation extends from depths of 902 to 1072 ft in CdV-R-37-2 (Appendix C). The fanglomerate consists of coarse volcaniclastic sediments as described by Griggs (1964, 8795) and by Waresback (1986, 58715). The dacitic detritus throughout the Puye fanglomerate at CdV-R-37-2 is dominated by clinopyroxene-porphyritic lithologies, although samples from the lowermost portion of the sequence show evidence of an increase in amphibole-porphyritic dacites (Appendix E). This lower part of the interval, from ~1047- to 1072-ft depth, has less coarse gravel and a higher proportion of sand, silt, and clay than the upper part of the interval. In thin section, these finer-grained deposits collected as cuttings consist of siltstone to sandstone fragments with mixed volcanic detritus (e.g, volcanic amphiboles, pyroxenes, and lava fragments) and plutonic minerals (abundant quartz with trace muscovite and microcline) cemented by a clay matrix; dacite gravels from this lower interval are chemically (column 3, Table 10.0-1), mineralogically (row 3, Table 10.0-2), and petrographically (Appendix E) similar to—and likely derived from—the underlying hornblende-bearing Tschicoma lavas (see section 10.1.5).

Borehole geophysical logs show little variation throughout the Puye fanglomerate at CdV-R-37-2. Zones of modest increase in free water are indicated in the CMR log for the depth intervals of 910–925 ft and 1052–1058 ft (see the CD attached to this report). Resistivity, however, varies widely, from ~20 to >2000 ohm-meters. Lower resistivity probably reflects conductivity in clay-bearing zones of the fanglomerate, whereas zones of abundant large clasts are less conductive. This variability in electrical properties contrasts with the uniformly high resistivity of the underlying dacite lavas (see section 10.1.5).

Chemical data were collected for two representative samples of the 2- to 4-mm sediment size fraction in the upper fanglomerate (the 907- to 912-ft depth and the 967- to 972-ft depth) and for a separate of the dacitic detritus (separated from cuttings of siltstone) at the 1062- to 1067-ft depth (Table 10.0-1, columns 1–3). There is very little difference between the samples, except for the slightly more mafic composition of the deepest sample (evident in higher ferrous oxide plus ferric oxide; higher magnesium oxide; and higher chromium, nickel, and strontium). In chemical composition as well as lithology, the fanglomerates are very similar to those from a comparable depth in drill hole R-25 (Broxton et al. 2002, 72640). Tschicoma sources for the detritus in these upper fanglomerates of R-25 are linked to the nearby volcanic centers of Pajarito Mountain or Cerro Grande; the same sources are likely contributors of dacitic detritus to the Puye fanglomerates of CdV-R-37-2. The deeper, more siliceous fanglomerates that were found at R-25 do not occur at CdV-R-37-2, where the thinner section of fanglomerates is underlain by a thick sequence of Tschicoma dacitic lavas.

A separate of the siltstone from the 1062- to 1067-ft depth of CdV-R-37-2 (Table 10.0-1, column 4) differs from the coarser dacitic detritus (Table 10.0-1, columns 1–3) in its higher LOI (which, in this sample, represents water content) and higher LOI-corrected silicon dioxide content (72% versus 67–68%). The siltstone also has a significantly higher proportion of ferric to ferrous iron; lower calcium oxide, sodium oxide, and potassium oxide contents; and higher abundance of transition elements indicative of heavy-mineral detritus (e.g., titanium, chromium, and zirconium). Taken together, these parameters indicate a deposit rich in hydrous minerals (clay) and resistant detritus such as quartz and zircon. The occurrence of highly oxidized iron in the siltstone indicates significant weathering.

Quantitative mineralogical analyses of Puye samples were performed by XRD (Table 10.0-2, rows 1–4) for splits of the same four samples that were analyzed chemically (Table 10.0-1, columns 1–4). The 2- to 4-mm size fractions of the upper Puye contain small amounts of glass (5–12%) but lack any evidence of glass alteration to clays or zeolites. This lack of alteration is also evident in the dacitic gravel constituent of the lower Puye sample at the 1062- to 1067-ft depth, which contains an even greater glass content (33.7%). However, the associated siltstone at the 1062- to 1067-ft depth contains no glass and has a high smectite content (35%), along with small amounts of kaolinite and zeolite. The occurrence of unaltered and relatively unoxidized glass-rich Tschicoma gravels, along with altered, oxidized, mixed-provenance siltstones, suggests a highly heterogeneous depositional system; similarity of the unaltered gravel to the underlying dacitic lavas (section 10.1.5) points to a very local gravel source mixed into sands, silts, and clays from distant sources.

10.1.5 Tschicoma Formation Dacitic Lavas [1072-ft depth to total depth (TD) at 1664 ft]

Lava flows of the Tschicoma Formation occur from depths of 1072 to 1664 ft (TD). The bottom of this sequence of lavas was not penetrated at CdV-R-37-2. Mixed-provenance siltstones were encountered at several depths in the upper 142 ft, but all of these are very immature, contain clasts of the associated dacites, and are limited to one or two cuttings runs in each occurrence. Such siltstones are rare; elsewhere, lavas or rubble zones between lavas predominate. The dacites are consistently amphibole-pyroxene porphyritic and are generally similar throughout in lithology. Three of the dacites were analyzed: one from lava at the 1072- to 1077-ft depth, one from clasts within an immature clastic interflow zone at the 1389- to 1394-ft depth, and one from lava at the 1654- to 1659-ft depth. The sample from the upper lava and the sample from the clastic deposit are most similar. The lower dacite sample is higher in calcium oxide and strontium than the upper lavas (column 8, Table 10.0-1). A visual examination of the cuttings suggests that this moderate change in chemical and petrographic composition occurs at ~1469-ft depth, with a transition to dacite lavas with mafic phenocrysts similar to those in the upper lavas but in greater abundance (Appendix C).

Phenocrysts common to all the dacitic lavas in CdV-R-37-2 include amphibole, clinopyroxene, orthopyroxene, and plagioclase. Quartz phenocrysts are rare, generally limited to the upper lavas, and in apparent disequilibrium (resorbed and rimmed by clinopyroxene crystals). The amphibole phenocrysts are variably fresh to heavily altered; fresh amphibole phenocrysts have strong yellow-red-green pleochroism. Clinopyroxene phenocrysts are pleochroic pink-yellow and often concentrically zoned; orthopyroxene is less abundant and clear to slightly colored. Plagioclase phenocrysts are variably sieved and concentrically zoned.

Borehole geophysical logs provide limited information for helping to define the transition from Puye fanglomerates to Tschicoma dacites. The strongest indication of transition from sediment to lava is a constant high resistivity within the lavas (>2000 ohm-meters), regardless of whether the lava is saturated or unsaturated, whereas resistivity varies from high to low (values as low as 20 ohm-meters) in the unsaturated fanglomerates (see the CD attached to this report). The total gamma, spectral gamma, and CMR logs show little difference across the transition from fanglomerate to lava. Significant rises in large-pore and late-decay water abundance are seen in the dacite lava at the top of the zone of regional saturation (the 1195- to 1205-ft depth; measured static water level is at the 1196.7-ft depth). However, this abundance of free water declines markedly in the 65-ft interval from 1205 to 1270 ft and drops periodically over thinner intervals (generally <20-ft thick) at greater depth. These intervals that are poor in free water are likely to be sections of dacitic lava with little vesicularity and minimal void space (void space within dacitic lavas probably arises from brecciation or fractures). The formation microimager (FMI) log indicates little smooth and massive fabric in the dacitic lavas; most of the lava structure seen is of angular blocks, although the zone with little large-pore or late-decay water at the 1205- to 1270-ft depth has a distinctive platy fabric with local concentric fracturing.

Cuttings collected throughout the Tschicoma series from the 1072-ft depth to TD are dominated by dacitic lava fragments, with the exception of the siltstones associated with angular dacite fragments in short cuttings runs at the 1082- to 1087-, 1102- to 1107-, and 1207- to 1214-ft depths (Appendix C). A sample of the siltstone at the 1207- to 1209-ft depth was analyzed for comparison with the Puye siltstone at the 1062-to 1067-ft depth (compare columns 4 and 6 in Table 10.0-1 and rows 4 and 5 in Table 10.0-2). There are only minimal differences between these siltstones in chemical composition and in mineralogy. Both are mixed-provenance siltstones cemented by clay, both contain comparable detritus from both volcanic and plutonic sources. The similarity leaves this question open: Were the siltstones deposited between dacitic lava flows or introduced from the surface by translocation of sand, silt, and clay along major fractures? The great thickness of dacite lavas (135 ft) above the siltstone sample from 1207 to 1209 ft makes transport from the overlying Puye along fractures very unlikely. In addition, the siltstone at the 1207- to 1209-ft depth between dacite lavas has a faint but distinctive fabric of deformed clay-bonded ooids that is not observed in the Puye Formation siltstone.

A zone of angular to subrounded dacite fragments with abundant clay occurs at the 1379- to 1414-ft depth, deep within the dacite lava series. Cuttings from this interval returned up to 25% of waxy, pale cream to flesh-colored clay. These clays are laminated and relatively free of silt-size detritus; in color and purity they differ markedly from the dark and detritus-laden clays associated with possible faults in the vadose zone (sections 10.1.1.4 and 10.1.3). XRD analysis of this deeper clay shows it to be a well-ordered smectite with no trace of relict mica, unlike the clays in possible fault zones which appear more similar to soil clays. The interval at the 1379- to 1414-ft depth is interpreted as an interflow deposit of coarse-clastic dacite detritus, with associated clays that formed at depth.

10.1.6 Stratigraphic Relation Between CdV-R-37-2 and Other Drill Holes

Figure 10.0-1 shows the location of two section lines linking CdV-R-37-2 with other drill holes at the Laboratory. One of these sections starts at drill hole SHB-3 and passes to the southeast, through CdV-R-37-2 to drill holes DT-5A, DT-10, DT-9, and R-31. The stratigraphies encountered in this set of drill holes are shown in Figure 10.1-2. The other section starts at CdV-R-37-2 and extends northward through drill holes R-25, H-19, and TW-4 (Figure 10.1-3). In both Figure 10.1-2 and Figure 10.1-3, the thick sequence of Tschicoma dacitic lavas at CdV-R-37-2 contrasts with the absence of similar lavas in the closest boreholes of comparable depth: the DT series in Figure 10.1-2 and R-25 in Figure 10.1-3. The absence of such lavas in the closest drill holes accounts for the prediction that no such lavas would be found at CdV-R-37-2 (Figure 10.0-2). The presence of the lavas at CdV-R-37-2 greatly alters the conceptual model of geology in the southwestern portion of the Laboratory.

Figure 10.1-2 illustrates the relatively sharp drop in elevation of the base of the Bandelier Tuff (base of the Guaje Pumice Bed) from SHB-3 to DT-5A, with the absence of any significant decline in the elevation of this horizon from DT-9 to R-31. If any horizons within the Bandelier Tuff were acting as perching horizons, the flow gradient at the base of the horizon would diminish to the southeast. Beneath the Bandelier Tuff, correlations are possible between the largely basaltic Cerros del Rio lavas from R-31 to DT-5A, but there is a discontinuity between DT-5A and the thick Tschicoma dacites in CdV-R-37-2. Although the Cerros del Rio and Tschicoma series overlap in age and even in composition (thin dacites are found intercalated with basalts in the Cerros del Rio), the style of volcanism is very different. This difference in style arises from the stacking of relatively thin flows with intervening scoria, breccia, or sediment horizons in the Cerros del Rio, contrasted with the massive Tschicoma flows with little horizonation (section 10.1.5). Evidence from drill hole R-9i indicates that open breccia between flows in the Cerros del Rio lavas can produce highly transmissive horizons (e.g., 37 ft/day; Broxton et al. 2001, 71251). The absence of such horizons in Tschicoma lavas is likely to result in less transmissive hydrogeologic properties and poorer lateral continuity in those transmissive zones that do occur (7.0 to 11.4 ft/day; see Table 12.2-1).

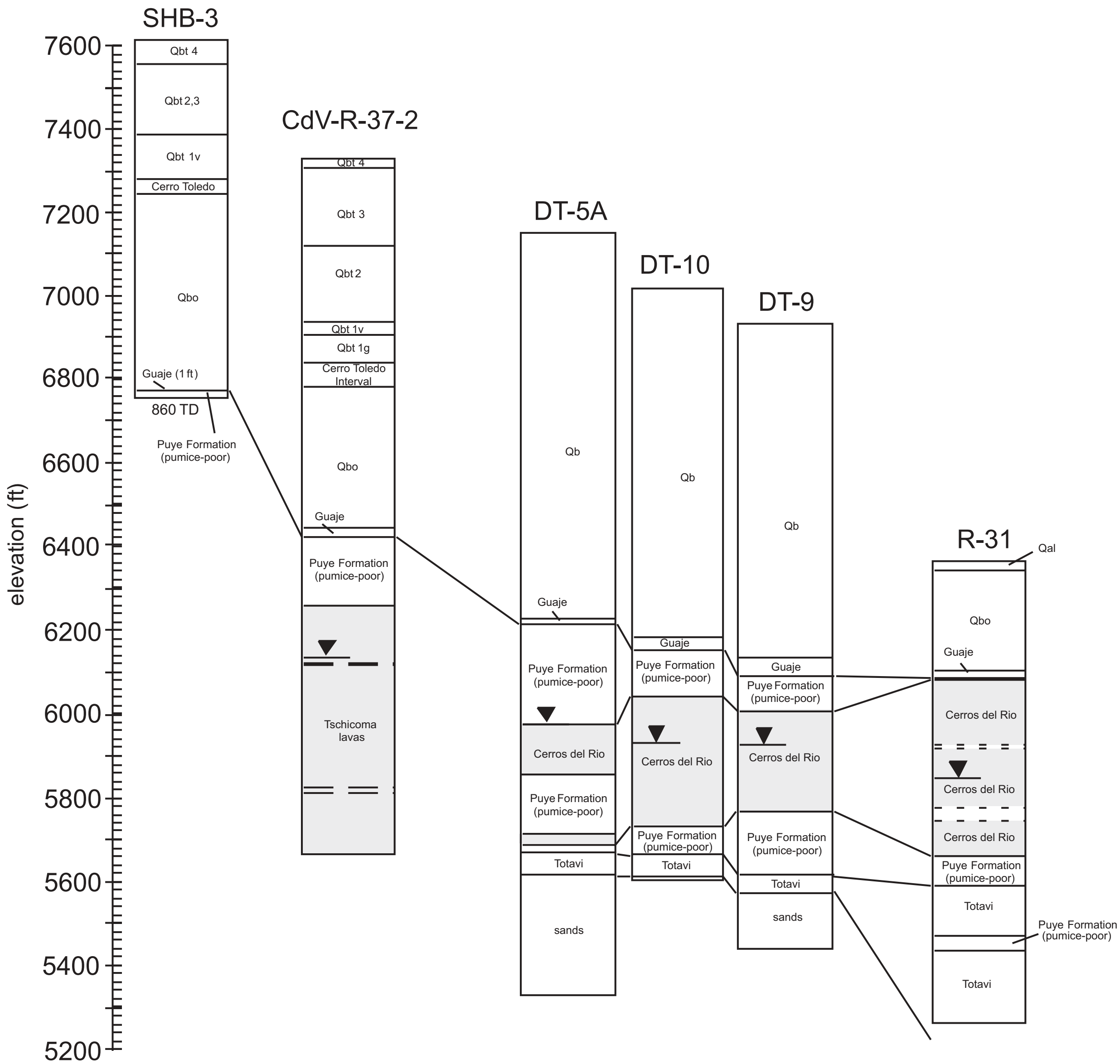


Figure 10.1-2. WNW-ESE drill hole correlations relating CdV-R-37-2 to SHB-3, the DT-series drill holes, and R-31
(see Figure 10.0-1 for location of drill holes)

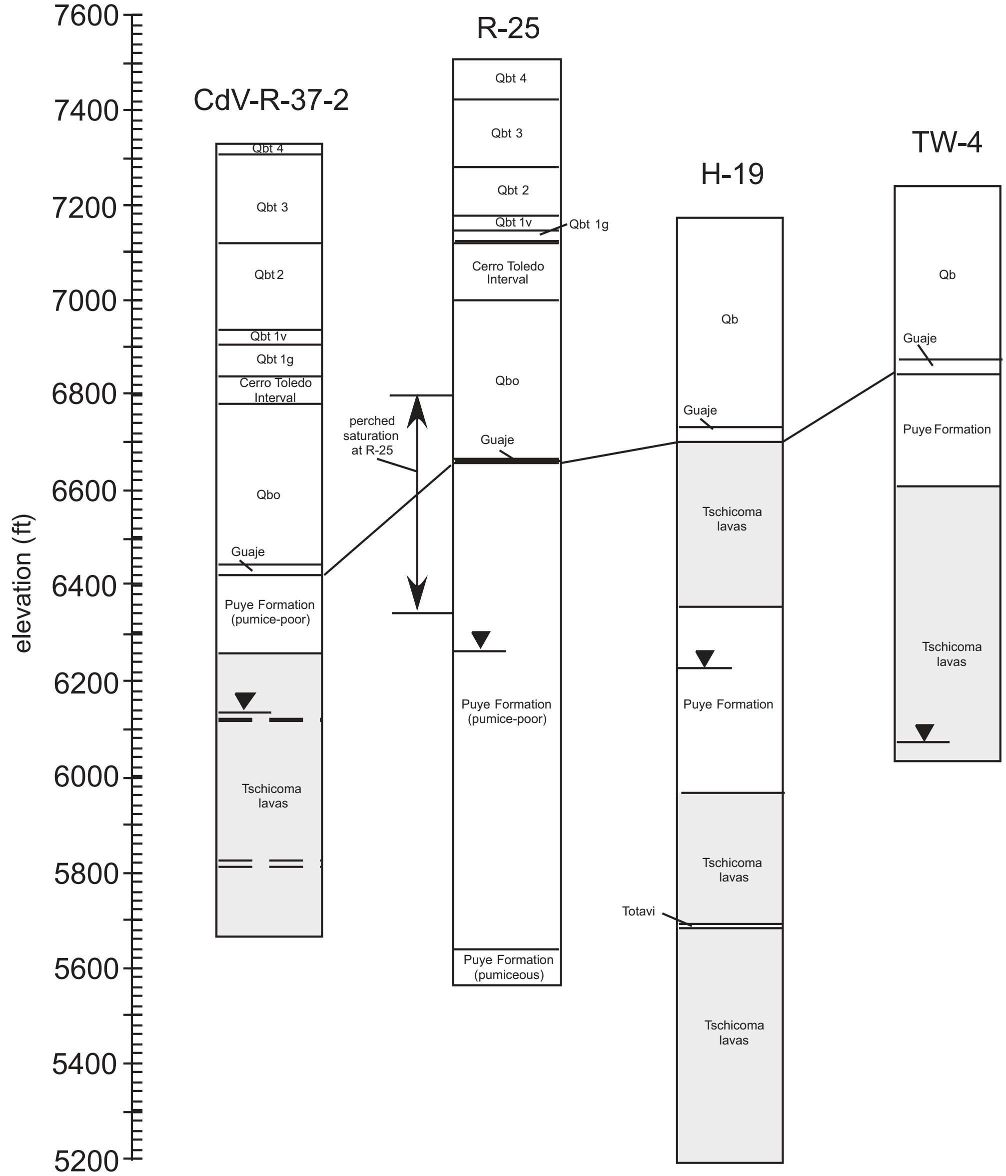


Figure 10.1-3. S-N drill hole correlations relating CdV-R-37-2 to R-25, H-19, and TW-4
(see Figure 10.0-1 for location of drill holes)

Figure 10.1-3 shows that, although there is a discontinuity represented by the occurrence of Tschicoma lavas at CdV-R-37-2 and the absence of such lavas at R-25, Tschicoma lavas of comparable thickness do occur at H-19 and TW-4 in the northwestern part of the Laboratory. The contrast between R-25 and these other drill holes at the western margin of the Laboratory indicates an embayment of thick Puye sedimentation in the west-central part of the Laboratory. These Puye sediments either abut or interfinger with Tschicoma lavas to the north (H-19, TW-4) and to the south (CdV-R-37-2). The thick perched zone at R-25 has no equivalent at CdV-R-37-2, despite the occurrence of comparable strata at comparable elevations in both drill holes. This indicates that the cause of perching at R-25 owes more to local recharge conditions than to hydrogeologic stratigraphy.

11.0 BOREHOLE GEOPHYSICS

ER Project contractors and Schlumberger Integrated Water Solutions personnel performed the suite of geophysical measurements on the CdV-R-37-2 well and interpreted these measurements.

On July 26, 2001, personnel from WGII (a contractor to the ER Project), ran the video camera, natural gamma, and array induction tools down the borehole. The total interval logged was 0–795 ft, with open hole conditions below 26 ft.

On August 6, 2001, upon completion of drilling, the video camera and natural gamma tool were used to log the hole. As the train of instruments was lowered into the borehole, the train encountered unstable borehole conditions at a depth of 1372 ft, and the video camera was temporarily stuck at 1369 ft. The interval logged with the natural gamma tool was 0–1290 ft, with open hole conditions below 825 ft.

Schlumberger personnel performed a total of seven geophysical measurement runs on CdV-R-37-2. The first run started on August 6, 2001. The remaining six runs (run numbers 2 through 7) were performed on August 7, 2001.

Schlumberger's measurements were taken and field-processed from the ground surface to 1665 bgs when the borehole contained 13.38-in.-OD steel well casing to a depth of 824 ft bgs and was a 12.25-in.-diameter open hole from 824 ft to TD. These preliminary data were used to identify water-bearing formations and to enable design and placement of well screens. Subsequently, Schlumberger reprocessed the field logs, correcting and improving the logs for environmental degradation of measurements and integrating the separate logs into a more coherent single presentation.

The primary purpose of Schlumberger's work was to acquire measurements that would help characterize the borehole and near-borehole hydrogeologic environment. Such information was used to design the well, help locate lithologic contacts, improve understanding of subsurface site conditions, and assist with decision-making.

The primary geophysical logging services that were performed, and the tools that were used to perform them, are described below.

- The borehole video (BV) made visual light video images of the borehole wall which were used to identify moisture on the borehole wall above the well water level and to examine the borehole's condition, particularly washouts.
- The array induction tool, version H (AITH), both measured formation resistivity which is, in turn, a function of water content, water salinity, and clay content, and indicated drilling fluid invasion.
- The gamma ray (GR) tool measured calibrated total gamma ray activity of the formation and was used for correlation between logging runs and identification of bentonite-rich versus sand annular fill after well completion.
- The compensated neutron tool, model G (CNTG), measured volumetric water content beyond the casing as a means of evaluating moist/porous zones and estimating porosity in the saturated zone.
- The hostile natural gamma spectroscopy (HNGS) tool measured overall and spectral natural gamma ray activity, including potassium, thorium, and uranium concentrations, as a means of evaluating geology/lithology and the presence of clay versus sand.
- The elemental capture spectroscopy (ECS) tool measured concentrations of hydrogen, silicon, calcium, sulfur, iron, potassium, titanium, and gadolinium as a means of characterizing the mineralogy, lithology, and water content of the formation.

- The FMI tool identified structural features such as bedding planes and determined structural strike and dip.
- The general purpose inclinometry tool (GPIT) measured borehole deviation and azimuth in open hole and was used to evaluate borehole position versus depth and to orient FMI images.
- The litho-density tool (LDT) measured bulk density and photoelectric effect as a means of estimating total porosity and characterizing lithology.
- The CMR tool measured the nuclear magnetic resonance response of the formation which was used to evaluate total and effective water-filled porosity of the shallow formation and to estimate pore size distribution and in-situ hydraulic conductivity.

In addition, to match the depth of logging runs, Schlumberger personnel recorded calibrated gross gamma ray readings with every service except HNGS and ECS.

Schlumberger personnel reported that the geophysical log measurements yielded high-quality results that were consistent with each other through much of the borehole, although the quality of some measurements from those tools that required contact with the borehole wall was degraded near the bottom (1284 to 1683 ft) due to washouts.

Schlumberger personnel concluded that the log results indicated that

- the depth of the regional aquifer water table appears to coincide with the water level in the well at the time of logging (1196.7 ft);
- the formation in the bottom section of the well (1365–1665 ft) has high total and effective porosity, averaging 35–40%, indicating very high groundwater flow capacity;
- the interval of 1075–1365 ft has lower porosity than the bottom zone, although it is also highly heterogeneous and contains some zones whose porosity greater than 40%;
- the interval of 895–1075 ft appears to be relatively clay-rich, containing zones with as much as 50% modeled clay volume fraction (the actual clay abundance in cuttings is much less);
- a marked increase in thorium, potassium, and uranium was distinguished in the logs at 887–902 ft, likely corresponding to the Guaje Pumice Bed; and
- water content decreased at 778 ft from 17% to 10%, diminishing to 10% or less up to ground surface.

(See the geophysical report on the attached CD for a more complete discussion of geophysical logging results.)

12.0 HYDROLOGY

Because CdV-R-37-2 is designed to identify the presence and movement of HE contamination, hydrologic observations were limited to the saturated zones. Therefore, this section addresses the occurrence and movement of groundwater at CdV-R-37-2.

12.1 Groundwater Occurrence

Based on data from R-25 and the sitewide geologic model, it was predicted that CdV-R-37-2 would encounter two zones of perched saturation as well as the regional zone of saturation. Perched water was expected in the lower part of the Otowi Member, Bandelier Tuff, at a depth of 700 ft and in the upper part of the Puye Formation at a depth of 850 ft. The regional water table was anticipated to lie within the axial gravels of the Puye Formation at a depth of 1167 ft.

12.1.1 First Saturation

Water-producing zones are usually readily detected during drilling. In an attempt to locate the predicted perched water, drilling was halted and the hole was blown dry at various depths between 584 and 1344 ft. Some water was found periodically in the borehole throughout this interval (e.g., at a depth of 757 ft), but because the water did not return after the hole was dried out, it was determined to have been introduced during drilling.

Performing video logging, after the hole is drilled, often gives a better definition of first saturation. Such logging at CdV-R-37-2 revealed the first show of water at a depth of 872 ft in the ash flows of the Otowi Member, Bandelier Tuff. The video tape shows the borehole wall to be wet essentially all the way from below that depth to the top of regional saturation. This was the result of water seeping from the formation in specific intervals, most notably between the depths of 934 and 977 ft in the Puye Formation.

12.1.2 Regional Saturation

At a depth of 1344 ft, in dacite, the driller suspected that the borehole had encountered saturation. After circulating fluid without drilling for 1 hr at that depth, there was still a strong flow. The hole was advanced 20 ft to a depth of 1364 ft and the water level was allowed to recover. The hole was not disturbed for a period of 14.5 hr, after which the water-level depth was measured at 1196.7 ft. This value was confirmed by two more measurements, at 0.3 and 1.7 hr after the initial reading. Saturation was noted to continue to TD. Because this water level is only 30 ft deeper than that projected for the top of regional saturation, it was concluded that the level represented the regional water table at CdV-R-37-2.

12.2 Groundwater Movement

Groundwater movement may be characterized in terms of a flow direction as well as a rate. Although data for evaluating horizontal flow direction cannot be provided by a single well, vertical direction of movement can be determined by analyzing head distribution along the borehole. A general idea of potential flow rate can be provided by the hydraulic properties determined from analyzing field test data.

12.2.1 Vertical Gradient

The direction of vertical gradient—whether groundwater movement in the third dimension is upward or downward—is best determined by comparing water-level depths or elevations (heads) from different borehole depths. If water-level depth increases (or head decreases) with borehole depth, the direction of the vertical gradient is downward. Conversely, if the water-level depth decreases (or head increases) with borehole depth, the direction of vertical gradient is upward.

Water-level measurements were taken at various depths during the course of drilling CdV-R-37-2. For example, when the borehole depth was 1364 ft, water-level depth was 1196.7 ft; when the borehole depth was 1664 ft, water-level depth was 1195 ft. Because of the considerable length of open hole at the time these measurements were taken, they are not true piezometric head values. However, even composite heads such as these can suggest the general direction of vertical movement. The data from CdV-R-37-2 suggest a generally downward vertical gradient direction at the well.

The downward vertical gradient was confirmed by two other sets of observations. The water-level depth measurements for screens 3 (1195.4 ft) and 4 (1195.2 ft) when isolated during straddle-packer/injection testing confirm a slightly downward gradient. The piezometric profile constructed from transducer measurements which were made at the time the Westbay system was installed also clearly shows a downward gradient.

A downward vertical gradient indicates that the well is located in a recharge area. This is not surprising given the mesa-top setting and is consistent with the conceptual hydrogeologic model of the western part of the Laboratory.

12.2.2 Hydraulic Properties

Field tests were conducted as described in section 7. Water-level response data were analyzed using the AQTESOLV software package for Windows. The preliminary results of the tests are given in Table 12.2-1.

Table 12.2-1
Summary of Straddle-Packer/Injection Testing at CdV-R-37-2

Screen (unit)	Injection Rate (gpm)	Volume Injected (gal)	K[a] (ft/d)	Analytical Method
3 (Tt[b])	11.5	23	7.0	Bouwer-Rice[c]
4 (Tt)	18.4	36.8	11.4	Bouwer-Rice

[a] K = hydraulic conductivity.

[b] Tt = Tschicoma Formation.

[c] From Bouwer and Rice 1976, 64056.

13.0 GEOCHEMISTRY OF SAMPLED WATERS

Well CdV-R-37-2 was sited and designed to evaluate the presence and mobility of anthropogenic constituents, particularly HE, downgradient of TA-16 to the south and east. CdV-R-37-2 is not a hydrologic characterization well; instead, it is designed to (1) bound the extent of contamination, presumed to derive from the 260 outfall, potentially affecting the regional aquifer and any perched aquifers present; (2) collect data to be used in the CMS for evaluating contaminant impact on potential receptors; and (3) determine if there is a threat to human health and the environment associated with groundwater contamination from PRS 16-021(c)-99, if detected. Thus, during drilling and installation of the well, the emphasis was on cost-effective drilling and the installation of a Westbay sampling system, rather than on hydrogeochemical characterization.

No perched water was identified in the well, and the regional aquifer was found to be contained within lavas of the Tschicoma Formation, with static water level (SWL) at 1196.7 ft. The sections below report briefly on the hydrogeochemical characterization that did occur during the drilling of CdV-R-37-2. During drilling, five discrete water samples were selected for analysis. Two screening samples of regional aquifer water were taken to determine if either drilling additives or bentonite was affecting water chemistry, and to test for the presence of HE. To help with this evaluation, an additional sample of the drilling fluid was taken. The remaining two samples were taken primarily to determine if HE or volatile organic compounds (VOCs) were present in the regional aquifer.

13.1 Methods

During drilling at CdV-R-37-2, groundwater was sampled from two depths within the regional aquifer: 1344 ft and 1600 ft. These samples were sent to external laboratories and analyzed for relevant suites of constituents, including HE, hydrogen isotopic composition (δD), oxygen isotopic composition ($\delta^{18}O$), nitrogen isotopic composition ($\delta^{15}N$), VOCs, and low-level tritium. Two samples were analyzed at EES-6 for inorganic constituents and HE; these are considered screening samples. Samples were filtered in the laboratory prior to analysis. The HE, VOC, and isotope samples were collected to determine if HE or VOCs were present in the borehole and to determine the provenance of the regional groundwater at this site. The two screening samples for geochemistry and HE, plus the sample of drilling fluid, were collected to evaluate possible regional aquifer water contamination associated with drilling. Table 13.1-1 presents a summary of information about the groundwater samples that were collected during the drilling of CdV-R-37-2.

Table 13.1-1
Summary of Request Numbers for Groundwater Samples Collected During Drilling of CdV-R-37-2

Sample Identification Number	Depth of Water Collection (ft)	Date Collected	HE	Geochemistry	δD	$\delta^{18}O$	$\delta^{15}N$	VOCs	Tritium
GW37-01-0012	1344	08/01/01	9503R	9503R	—[a]	—	—	—	—
GW37-01-0013	na[b]	07/27/01	9500R	9500R	—	—	—	—	—
GW37-01-0014[c]	1344	08/01/01	9519R	—	9521R	9521R	9522R	9518R	9523R
GW37-01-0015	1600	08/04/01	9517R	9517R	—	—	—	—	—
GW37-01-0016[c]	1600	08/04/01	9519R	—	9521R	9521R	9522R	9518R	9523R

[a] — = Not analyzed.

[b] na = Not applicable; sample of drilling fluid.

[c] Only samples GW37-01-0014 and GW37-01-0016 were sent off-site for analysis. All other samples were analyzed in EES-6 (within LANL) and are therefore considered screening samples.

Additional groundwater samples will be collected quarterly and will be reported on in the PRS 16-021(c)-99 CMS report.

13.2 Geochemistry of the Regional Aquifer—Tschicoma Formation Dacitic Lavas

Groundwater samples collected during drilling were diverted through an exchange port 8 ft above the drill bit and then airlifted through the center tube of the drill pipe to the surface where collection occurred. Temperature, turbidity, pH, and specific conductance were determined on-site from an aliquot collected during field sampling. Field parameters are presented in Table 13.4-1. All samples collected in the field were stored at 4°C until they were analyzed.

Groundwater samples were analyzed using techniques specified in Environmental Protection Agency (EPA) publication SW-486, including high performance liquid chromatography (HPLC) for explosives; ion chromatography for anions such as chloride, bromide, fluoride, nitrate, phosphate and sulfate; and graphite furnace atomic absorption (GFAA) and inductively coupled plasma emission spectroscopy (ICPES) for cations such as boron, calcium potassium, lithium, magnesium, sodium, and silica. Bicarbonate was analyzed using titration methods. Stable isotopes of oxygen (oxygen-18 and oxygen-16), hydrogen (hydrogen and deuterium), and nitrogen (nitrogen-15 and nitrogen-14) were analyzed using isotope ratio mass spectrometry (IRMS). Low-level tritium was analyzed by electrolytic enrichment at the University of Miami. VOCs were analyzed by gas chromatography/mass spectrometry (GC-MS) at General Engineering Laboratory.

Laboratory blanks were collected and analyzed in accordance with EPA and LANL procedures. The analytical precision for cations and anions was generally ±10%.

13.3 HE and VOCs

No HE, HE-degradation products, or VOCs were detected. A potential acetone detect for sample GW37-01-0016 has been reclassified as undetected following focused validation. The acetone detect resulted from interference related to isopropyl alcohol contained in the QUIK-FOAM drilling additive (Longmire 2002, 72800.2).

13.4 Quality of Groundwater Within the Tschicoma Formation

Field-measured parameters for the borehole groundwater samples, including specific conductance, pH, temperature, and turbidity, are provided in Table 13.4-1.

Table 13.4-1

Field Parameters for Water Samples from CdV-R-37-2

Sample Identification Number	Depth of Water Collection (ft)	Conductance (µS/cm)	pH	Temperature[a] (°C)	Turbidity (NTU)
GW37-01-0012	1344	119.6	8.06	34	526
GW37-01-0014	1344	119.6	8.06	34	526
GW37-01-0015	1600	119.8	7.69	23.5	57
GW37-01-0016	1600	119.8	7.69	23.5	57

[a] Air used to lift the water heats it on the way up to the surface.

The screening analytical results for the samples from 1344 and 1600 ft are shown in Table 13.4-2.

Table 13.4-2

Hydrogeochemistry of Screening Samples from CdV-R-37-2

	Sample from 1344-ft Depth	Sample from 1600-ft Depth	Sample of Drilling Fluid
Geologic unit	Tschicoma Formation	Tschicoma Formation	NA[a]
Sample treatment	Filtered	Filtered	Filtered
Date sampled	08/01/02	08/04/02	07/27/01
Alkalinity (Lab) ($CaCO_3$) (ppm)	50.3	50.3	110.7
Aluminum (ppm)	0.066	0.014	1.04
Ammonium (ppm)	0.08	[0.02][b]U[c]	11.6
Antimony (ppm)	[0.002]U	[0.002]U	0.0011
Arsenic (ppm)	0.0004	0.0011	0.0008
Barium (ppm)	0.006	0.009	0.039
Beryllium (ppm)	[0.001]U	[0.001]U	[0.001]U
Bicarbonate (ppm)	61.4	61.4	135
Boron (ppm)	0.008	0.006	0.027
Bromide (ppm)	0.02	0.01	[0.02]U
Calcium (ppm)	7.73	8.52	25.1
Cesium (ppm)	[0.001]U	[0.001]U	0.0013
Chlorate (ppm)	[0.02]U	[0.02]U	[0.02]U
Chloride (ppm)	1.78	1.69	7.41
Chromium (ppm)	[0.001]U	[0.001]U	0.0025
Cobalt (ppm)	[0.001]U	0.0012	0.0077

Table 13.4-2 (continued)
Hydrogeochemistry of Screening Samples from CdV-R-37-2

	Sample from 1344-ft Depth	Sample from 1600-ft Depth	Sample of Drilling Fluid
Copper (ppm)	[0.001]U	[0.001]U	0.012
Fluoride (ppm)	0.20	0.17	0.88
Hardness ($CaCO_3$) (ppm)	30.6	32.1	85.6
Iodide (ppm)	[0.01]U	[0.01]U	[0.01]U
Iron (ppm)	0.069	0.11	0.42
Lead (ppm)	[0.001]U	[0.001]U	0.0014
Lithium (ppm)	0.025	0.023	0.062
Magnesium (ppm)	2.75	2.62	5.57
Manganese (ppm)	0.021	0.011	0.82
Mercury (ppm)	0.00007	0.00008	0.00016
Molybdenum (ppm)	0.0019	0.0012	0.055
Nickel (ppm)	[0.001]U	[0.001]U	0.024
Nitrate (ppm)	1.83	1.67	0.21
Nitrite (ppm)	[0.01]U	[0.01]U	9.12
Oxalate (ppm)	[0.02]U	[0.02]U	2.57
Perchlorate (ppm)	[0.002]U	—[d]	[0.02]U
pH (Lab)	7.90	7.70	7.60
Phosphate (ppm)	[0.02]U	[0.02]U	0.04
Potassium (ppm)	1.62	1.42	11.4
Rubidium (ppm)	0.0038	0.0027	0.073
Selenium (ppm)	[0.001]U	[0.001]U	[0.001]U
Silica dioxide (ppm)	54.8	64.6	34.5
Silver (ppm)	[0.001]U	[0.001]U	[0.001]U
Sodium (ppm)	10.7	9.57	38.9
Strontium (ppm)	0.041	0.049	0.13
Sulfate (ppm)	1.7	1.55	41.5
Thiosulfate (ppm)	[0.01]U	[0.01]U	[0.01]U
Thorium (ppm)	[0.001]U	[0.001]U	[0.001]U
Tin (ppm)	[0.001]U	[0.001]U	[0.001]U
Titanium (ppm)	[0.001]U	[0.001]U	0.015
Total dissolved solids (TDS) (ppm)	144.8	153.5	326.5
Uranium (ppm)	[0.001]U	[0.001]U	0.0029
Vanadium (ppm)	0.002	0.007	0.004
Zinc (ppm)	[0.001]U	0.002	0.024
HMX (1,3,5,7-tetranitro-1,3,5,7-tetrazacyclo-octane) (ppm)	[0.01]U	[0.01]U	[0.02]U

Table 13.4-2 (continued)
Hydrogeochemistry of Screening Samples from CdV-R-37-2

	Sample from 1344-ft Depth	Sample from 1600-ft Depth	Sample of Drilling Fluid
RDX (1,3,5-trinitro-1,3,5-triazacyclohexane) (ppm)	[0.01]U	[0.01]U	[0.02]U
TNT (trinitrotoluene) (ppm)	[0.01]U	[0.01]U	[0.02]U
1,3-DNB (dinitrobenzene)	[0.01]U	[0.01]U	[0.02]U
NB (nitrobenzene) (ppm)	[0.01]U	[0.01]U	[0.02]U
1.3.5-TNB (trinitrobenzene) (ppm)	[0.01]U	[0.01]U	[0.02]U
2,4-DNT (dinitrotoluene)	[0.01]U	[0.01]U	[0.02]U
2a-4,6-DNT (ppm)	[0.01]U	[0.01]U	[0.02]U
Anion sum (MEQ[e])	1.133	1.123	3.535
Cation sum (MEQ)	1.140	1.106	4.519
Balance (%)	+0.59	-1.55	+24.43

[a] NA = not applicable.

[b] Bracketed value is the detection limit.

[c] U = less than detection.

[d] — = not analyzed.

[e] MEQ = millequivalents.

Note: Data in this table are screening level (samples were not sent to off-site laboratories; they were analyzed by LANL internally).

Groundwater from the regional aquifer at CdV-R-37-2 is a calcium-sodium-bicarbonate type, as shown in the laboratory-filtered samples collected at both 1344 and 1600 ft. TDS values are low (144.8 to 153.5 ppm) and similar to, or lower than, the TDS values for samples from the regional aquifer collected at the R-25 well (Broxton et al. 2002, 72640). Most major cations and anion constituent abundances are similar to the values measured in R-25, which was drilled using few, if any, drilling additives. The values are also similar to those found at CdV-R-15-3 (Kopp et al. 2002, 73179.9).

Concentrations of constituents that are indicative of bentonite interactions with groundwaters, such as sodium and sulfate, are low (9.57–10.7 ppm and 1.55–1.7 ppm, respectively) in the regional aquifer in CdV-R-37-2. These values are similar to those measured in the regional aquifer in boreholes drilled with minimal bentonite addition. They are also significantly lower than values measured in wells such as R-15 (Longmire et al. 2001, 70103). These results suggest that waters in the regional aquifer at CdV-R-37-2 have not had their chemistry significantly modified by interaction with introduced bentonite and drilling fluids.

At 1344 ft, deuterium and oxygen isotope values are –75‰ and –11.4‰, respectively. At 1600 ft, deuterium and oxygen isotope values are –78‰ and –11.6‰, respectively. These values fall very close to those of the Jemez Mountain meteoric water line, suggesting that the regional groundwater in CdV-R-37-2 is recharged from a meteoric source. At 1344 ft, water has a tritium content of 4.28 pCi/L, suggesting that a small amount of water recharging the system is less than 50 years old. The lack of contaminants in the water and the very low tritium values suggest recharge from west of the Laboratory. Additional characterization samples will help further this assessment.

Nitrate is the dominant form of nitrogen at CdV-R-37-2. Nitrogen isotope values for nitrate are +3.7‰ and +3‰ at 1344 ft and 1600 ft, respectively. The values are consistent with nitrogen derived from soil organic matter (Clark and Fritz 1997, 59168). These levels also could have resulted from low levels of denitrification of an isotopically lighter (i.e., enriched in ^{14}N) background source of nitrogen, under anaerobic/reducing conditions, perhaps related to the presence of drilling compounds (c.f. Ball et al. 2002, 71471.1; Longmire 2002, 72800.2). As mentioned previously, however, the chemistry of the groundwater suggests that significant interaction with drilling fluids did not occur. Levels of iron and manganese are also low, which is contrary to what would be expected under reducing conditions. Measurements of $\delta^{18}O$ of nitrate could be used to assess this nitrate source effect versus any fractionation associated with denitrification.

Overall, waters at CdV-R-37-2 appear to be

- relatively unaffected by drilling compounds,
- uncontaminated in general, and
- derived from a meteoric source with some small fraction of young water.

13.5 The Geochemical Model

The geochemical data collected from the two depth intervals at CdV-R-37-2 are generally consistent with the current geochemical conceptual model for the regional aquifer. Water quality is generally excellent in the borehole, and water chemistry is compatible with previous analyses of uncontaminated regional groundwater. Initial data suggest that the regional aquifer is not affected by HE contamination at this site. Planned quarterly sampling will provide a more reliable evaluation of groundwater quality at this location.

14.0 IMPLICATIONS OF CdV-R-37-2 FOR THE CONCEPTUAL HYDROGEOLOGIC MODEL

14.1 Geologic Implications

The implications of new information from CdV-R-37-2 for geologic models can be seen in Figure 10.0-2. That figure provides a stratigraphic comparison of CdV-R-37-2 with the Laboratory's 3-D geologic model that was current at the time of drilling. It is important to note that the conclusions reached in this report are subject to revision as more data are collected from CdV-R-37-2 and from other drill holes at the Laboratory. For example, the assignment of the dacitic lavas below 1072 ft in CdV-R-37-2 to the Tschicoma Formation would have to be revised if radiometric dating were to place these lavas within the older Keres Group volcanic cycle. It is also possible that fine-grained plutonic detritus (e.g., muscovite and microcline) in the siltstones above and between dacite flows at CdV-R-37-2 may ultimately be attributed to sources equivalent to those for Santa Fe Group sediments. The stratigraphic interpretation provided in Figure 10.0-2 is considered the most likely based on the data presently available.

The chief difference between the predicted and as-drilled stratigraphies in Figure 10.0-2 is the occurrence of thick dacitic lavas where they had not been anticipated. Figure 14.1-1 focuses on the Tschicoma and Cerros del Rio lavas in CdV-R-37-2, and in other drill holes at the Laboratory, to illustrate the effect that the thick dacitic lavas in CdV-R-37-2 have on the 3-D geologic model. In this figure it is evident that most of the central and eastern Laboratory is underlain by Cerros del Rio lavas. The figure identifies these as "Cerros del Rio-style" lavas because of their hydrogeologic structure, which includes strong horizonation into layers of variable transmissivity (section 10.1.6). In contrast, the "Tschicoma-style" lavas are thick dacitic masses with little continuous horizontal structure.

When constructing the 3-D geologic model, one dilemma is the nature of the transition between these two lava types: Do they interfinger or abut, or were Puye sediments deposited along the line marked *transition* *unknown* in Figure 14.1-1, between the Tschicoma dacitic highlands to the west and contemporaneous Cerros del Rio lava plateaus to the east, blocking direct contact between the two volcanic series? The impact of these conceptual differences will be minimal as long as flow paths are generally west to east; most contaminant transport pathways are unlikely to pass through dacitic lavas in the southwestern portion of the Laboratory. More important is the extensive region beneath the southeastern Laboratory where the surface of regional saturation lies within Cerros del Rio lavas (Figure 14.1-1). If, as evidence suggests, hydraulic gradients are flat or upward within the eastern portion of the Laboratory, then most transport pathways from contaminant sources in the southern Laboratory to eastern receptors will lie within Cerros del Rio lavas.

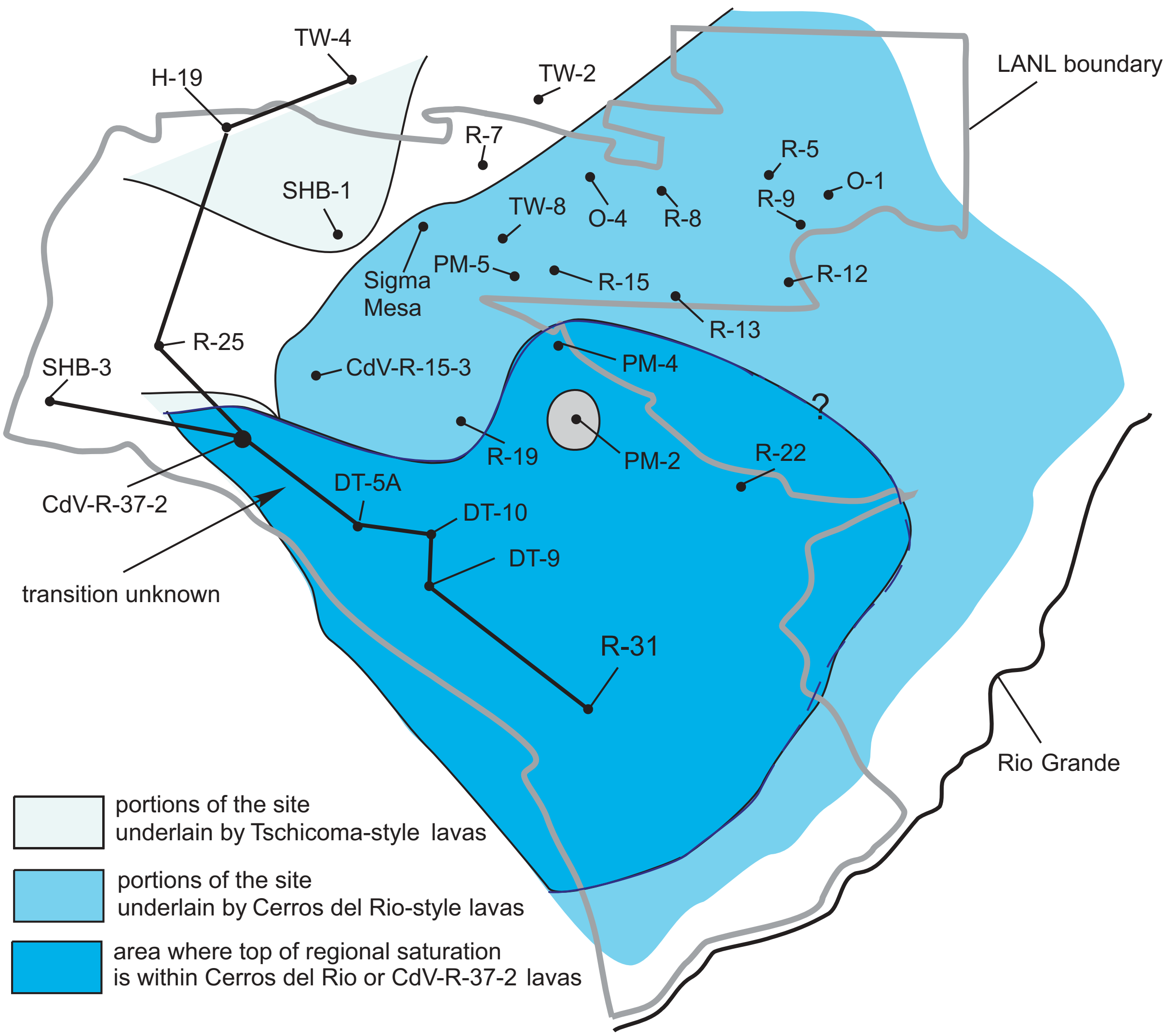


Figure 14.1-1. Extent of lavas and their intersection with the top of regional saturation at the Laboratory

14.2 Hydrologic Implications

Hydrologic observations at CdV-R-37-2 contribute significantly to the conceptual hydrogeologic model for the Laboratory. The well's location provided an excellent opportunity for investigating the occurrence and movement of perched and regional saturation in the western portion of the Laboratory. Of special interest is the absence of the thick perched zone which was encountered at R-25. Also significant is the occurrence of regional saturation in the Tschicoma Formation in this area. Wells drilled early in the Laboratory's history (H-19, TW-4) revealed that this was the case, but little information has been collected in the area since. Hydrologic testing at CdV-R-37-2 increased the number of hydraulic-property values available for the Tschicoma across the Pajarito Plateau from one to three. The composite head values suggesting a downward vertical gradient confirm the current conceptual model that the well is located in a recharge area.

14.3 Geochemical Implications

The geochemical data collected from the two depth intervals for CdV-R-37-2 are generally consistent with the current geochemical conceptual model for the regional aquifer. Water quality is generally excellent in the borehole, and water chemistry is compatible with previous analyses of uncontaminated regional groundwater. Initial data suggest that the regional aquifer is not impacted by HE contamination at this site. Planned quarterly sampling will provide a more reliable evaluation of groundwater quality at this location.

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A. Sherard was the host facility point-of-contact for administrative oversight for ESA Division.

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D. Counce performed the water chemistry analyses used for screening groundwater collected from saturated zones.

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D. Hickmott and the Groundwater Investigations Focus Area participated in the planning and evaluation of data collected during this investigation.

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J. Young of NMED provided regulatory oversight during drilling operations. M. Dale acted as liaison with the regulators.

A. Groffman, K. Van der Poel, L. Woodworth, D. Broxton, P. Longmire, R. Bohn, and C. Vidlak reviewed this document.

L. Levine was the editor and compositor for this document.

J. McCann supported all phases of this investigation as leader of the Groundwater Investigations Focus Area.

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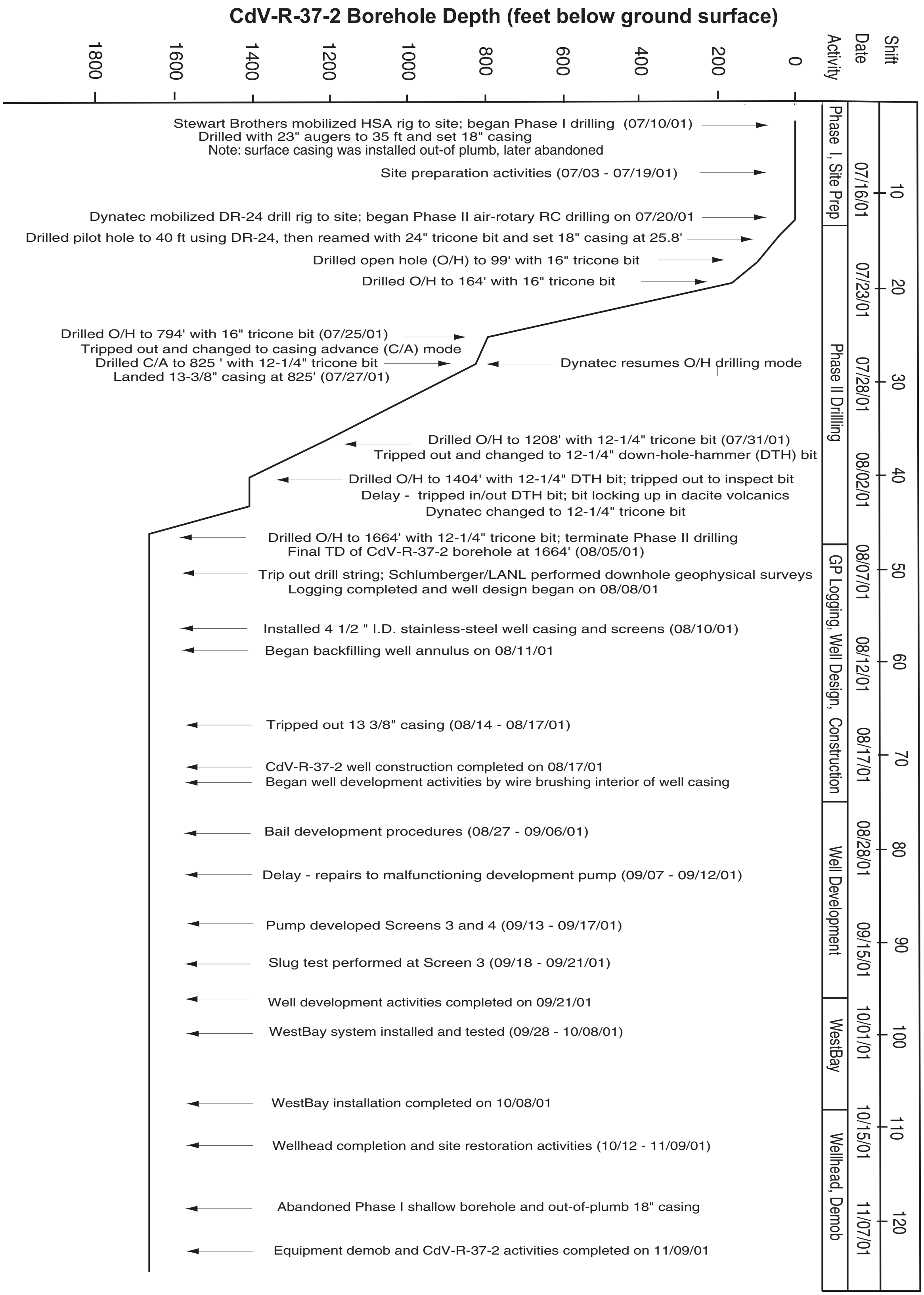
Appendix A

Diagram of Site Activities
Related to Progress



Well CdV-R-37-2 Operations Chronology Graph

Appendix B

Activities Planned for CdV-R-37-2,
Compared with Work Performed

Activity	Addendum to CMS Plan for PRS 16-021(c)	CdV-R-37-2 Field Implementation Plan	Actual Work
Planned Location	Well to be located to the southeast of TA-16-260 and R-25 at TA-11 (*Note:* Well is referred to as CdV-R-11-2 in this report)	Located at the west end of TA-37, downgradient in a southeastwardly direction from R-25 and the 260 outfall at TA-16 (*Note:* Well is referred to as CdV-R-37-2 in this report)	Located at the west end of TA-37, downgradient in a southeastwardly direction from R-25 and the 260 outfall at TA-16 (*Note:* Well is referred to as CdV-R-37-2 in this report)
Planned Depth	Total of 1800 ft, or at least 200 ft into the regional zone of saturation	Approximately 1850 ft, or 200 ft beyond the maximum depth of detected HE contamination as detected by screening analysis	Total drill depth of 1664 ft, approximately 469 ft below the regional water table
Drilling Method	Casing advance to total depth of borehole	Hollow-stem auger and casing advance/open hole, air rotary equipment	Hollow-stem auger and casing advance/ open hole, air rotary equipment
Amount of Core	Five percent of the borehole	No core planned	No core attempted
Lithologic Log	Log to be prepared from core, cuttings, and drilling performance	Log to be prepared from cuttings, geophysical logs, and drilling performance	Log made from cuttings, geophysical logs, and drilling performance
Number of Water Samples Collected for Contaminant Analysis	Not specified GW37-01-0012, explosives, 1344 ft; GW37-01-0013, explosives, 795 ft; GW37-01-0014, oxygen/hydrogen isotopes—explosives/plus RDX breakdown products, low-level tritium, nitrogen isotopes, volatile organic analytes, 1344 ft; GW37-01-0015, explosives, 1600 ft; GW37-01-0016, all the same tests as 0013, 1600 ft	One water sample to be collected from each saturated zone; geochemistry project leader and technical team to determine number and locations of samples based on conditions encountered; number of sampling events after well completion not specified; up to five water samples planned	Water samples collected from 795, 1344, and 1600 ft bgs
Water Sample Analysis	HE, metals, anions (nitrate, sulfate), fluoride, chloride, bromide, HCO_3 (bicarbonate), VOCs, gross alpha, gross beta	HE (degradation), HE, HE (screening), low-level tritium, anions + ClO_4^- (dissolved), metals, VOCs, NH_4, NO_3 + NO_2; stable isotopes: $^{18}O/^{16}O$, D/H, $^{15}N/^{14}N$, ClO_4^-	Stable and radiogenic isotopes: $^{18}O/^{16}O$, D/H, $^{15}N/^{14}N$; radionuclides: tritium, gross alpha, gross beta, gross gamma; organic compounds: VOCs, HE, metals, anions
Water Sample Field Measurements	HE spot test and D TECH immunoassay	pH, specific conductance, temperature, turbidity	pH, specific conductance, temperature, turbidity

Activity	Addendum to CMS Plan for PRS 16-021(c)	CdV-R-37-2 Field Implementation Plan	Actual Work
Number of Core/Cuttings Samples Collected for Contaminant Analysis	Samples of core or cuttings to be analyzed for potential contaminant identification in each borehole.	Up to 10 cuttings samples planned; number of samples dependent upon number of saturated zones encountered	No core or cuttings samples submitted for contaminant analysis
Core/Cuttings Samples Analytes	HE, metals, anions (nitrate, sulfate), fluoride, chloride, bromide, HCO_3 (bicarbonate), VOCs, gross alpha, gross beta	HE, metals, and anions	No samples submitted
Laboratory Hydraulic-Property Tests	Physical properties analyses to be conducted on five core samples and typically include moisture content, porosity, particle density, bulk density, saturated hydraulic conductivity, and water retention characteristics	Selected unsaturated materials may be tested in the laboratory for the full suite of hydraulic properties	No core samples
Geology	Five samples of cuttings or core to be collected from saturated zones for petrographic, XRF, and XRD analyses	Geology task leader to determine number of samples for characterization of mineralogy, petrography, and rock chemistry based on geologic and hydrologic conditions encountered during drilling	Fourteen samples were characterized for mineralogy, petrography, and rock chemistry
Geophysics	In general, open-hole geophysics includes caliper, electromagnetic induction, natural gamma, magnetic susceptibility, borehole color videotape (axial and side scan), fluid temperature (saturated), fluid resistivity (saturated), single-point resistivity (saturated), and spontaneous potential (saturated). In general, cased-hole geophysics include gamma-gamma density, natural gamma, and thermal neutron	In general, open-hole geophysics includes caliper, electromagnetic induction, natural gamma, magnetic susceptibility, borehole color videotape, fluid temperature (saturated), fluid resistivity (saturated), and spontaneous potential (saturated) In general, cased-hole geophysics include gamma-gamma density, natural gamma, and thermal neutron	Video (LANL tool): 0-768 ft and 795-1372 ft, natural gamma (LANL tool): cased: 0-822 ft, open hole: 25.8-794 and 822-1290 ft bgs, induction log (LANL tool): 0-794 ft Schlumberger geophysics (0-822 ft cased, 822-1656 ft open hole): compensated thermal and epithermal neutron, spectral gamma, CMR, FMI, elemental capture sonde, array induction, and litho-density
Water-Level Measurements	Measurements to profile head gradients	Water levels will be determined for each saturated zone by water-level meter or by pressure transducer. Additional water-level readings are to be made at as many borehole depths as possible for vertical gradient determination	Water-level meter determined water levels for the regional water table. Water levels in the perched water zone (screened at 914.4-939.5 ft bgs) were not measured during drilling.
Field Hydraulic-Property Tests	At key geologic intervals as determined by the technical team's hydrologist	Slug or pumping tests may be conducted in saturated intervals once the well is completed	Injection test on Screen 3

Activity	Addendum to CMS Plan for PRS 16-021(c)	CdV-R-37-2 Field Implementation Plan	Actual Work
Surface Casing	Approximately 16-in. OD casing from land surface to 10-ft depth	18-in. OD steel casing will be installed and cemented in place to isolate the borehole from surface water and alluvial groundwater (no specific depth given).	18-in. outside diameter steel casing set at 25.8' and cemented in place.
Minimum Well Casing Size	5.56-in OD	5.56-in. OD	5.0-in OD (4.5-in. ID) stainless-steel casing w/ external couplings (5.56-in. OD).
Well Screen	Number and length of screens to be finalized in the field, in consultation with NMED personnel based on site-specific findings	Well screen shall be constructed with multiple sections of wire wrapped 5.56-in. OD, pipe-based stainless steel screen, with a 0.01 in. slot size	Screened intervals constructed of 5.56-in OD (4.5-in. ID) pipe based, stainless steel, wire wrapped, 0.010-in slotted screen.
Filter Material	Filter pack shall be sized based on formation grain size and characteristics	Primary filter pack shall consist of round, clean, washed and resieved silica sand with a uniformity coefficient of 2.0 or less, placed 10 ft above and 5 ft below the well screen. The size of the filter pack shall be selected based on the characteristics of the formation to be screened. Secondary filter pack is finer silica sand placed 3 ft below and 5 ft above the primary pack	Primary filter pack constructed of 8/12 and 20/40 silica sand placed approximately 5 to 7 feet below and 5 to 10 feet above the screen. Secondary filter pack of 20/40 or 30/70 silica sand constructed in a nominal 2-ft-thick layer above and below the primary filter pack.
Conductor Casing	Carbon-steel casing from land surface to top of stainless-steel casing	Carbon-steel casing 5.56-in. in diameter extending from land surface to dielectric coupling at top of stainless-steel casing	None. Stainless steel to ground surface.
Backfill Material (exclusive of filter materials)	Cement grout and bentonite	Bentonite in borehole below well; fine sand in transition zone; bentonite above transition zone to bottom of surface casing; cement grout between surface casing and borehole wall and between surface casing and well casing	Bentonite pellets in borehole below well, fine sand in transition zone; bentonite above transition zone to bottom of surface casing; cement grout between surface casing and borehole wall and between surface casing and well casing. Two cement grout plugs and cement from surface to 77 ft bgs.

Activity	Addendum to CMS Plan for PRS 16-021(c)	CdV-R-37-2 Field Implementation Plan	Actual Work
Sump	Approximately 10 ft of blank with an end cap	5.56-in. diameter stainless-steel casing, 30 ft long	5.56-in diameter stainless-steel casing, 31.3 ft long
Bottom Seal	Bentonite	Bentonite	Bentonite

Appendix C

Lithologic Log

LOS ALAMOS NATIONAL LABORATORY
ENVIRONMENTAL RESTORATION
REMEDIAL ACTIONS FOCUS AREA
BOREHOLE LOG

BOREHOLE ID: CdV-R37-2	TA/OU: TA-37	Page 1 of 22
DRILLING COMPANY: Tonto Drilling Co.	START DATE: July 2001	END DATE: August 2001
DRILLING EQ/METHOD: Foremost DR24		SAMPLING EQ/METHOD: Cuttings
GROUND ELEVATION: 7330.6' asl DRILLER: Thoren, Wilson, Woodward		TOTAL DEPTH = 1664' bgz GEOLOGY P.I.: Vaniman

Depth (ft)	Elevation (ft)	Core Run # (amt.-recov./amt. attemp.)	Core Run	Cuttings Collected	Geologic Characterization (Depth Interval)	Moisture/Matric Pot.	Lithology	Graphic Log	Lithologic Symbol
0	7330	No core attempted			Geologic (5-10 ft) Geologic (40-44 ft)	No samples collected			Qbt4 (0–25 ft) Qbt3 (25–49 ft)
5	7325								
10	7320								
15	7315								
20	7310								
25	7305								
30	7300								
35	7295								
40	7290								
45	7285								

Lithology

QBT 4 TSHIREGE MEMBER, BANDELIER TUFF: (0-5 ft) Volcanic tuff, grayish orange (10YR 7/4), phenocrysts of quartz, sanidine, minor small pumice, some flattening and bending of pumice fragments indicate locally strong welding; groundmass glassy with shards.

QBT 4 TSHIREGE MEMBER, BANDELIER TUFF: (5-10 ft) Volcanic tuff, grayish orange (10YR 7/4), phenocrysts of quartz, sanidine, unidentified dark mineral (pyroxene?), rare quartz, pumice commonly showing some bending, partly welded glassy groundmass.

QBT 4 TSHIREGE MEMBER, BANDELIER TUFF: (10-15 ft) Volcanic tuff, grayish orange (10YR 7/4), phenocrysts of sanidine, some quartz, pumice (undeformed) common, pumice and groundmass glassy (vitric).

QBT 4 TSHIREGE MEMBER, BANDELIER TUFF: (15-25 ft) Volcanic tuff, pale orange (10YR 8/2), phenocrysts of sanidine, some quartz, pumice (up to 1.5 cm, undeformed) is common, minor volcanic lithic fragments (latite?); pumices slightly flattened indicating partly welded tuff.

QBT 3 TSHIREGE MEMBER, BANDELIER TUFF: (25-35 ft) Volcanic tuff, grayish orange-pink (5YR 7/2), phenocrysts of quartz, sanidine; minor pumice, non-welded matrix.

QBT 3 TSHIREGE MEMBER, BANDELIER TUFF: (35-40 ft) Volcanic tuff. No sample collected.

QBT 3 TSHIREGE MEMBER, BANDELIER TUFF: (40-44 ft) Volcanic tuff, grayish orange-pink (5YR 7/2), phenocrysts of quartz and sanidine; abundant lithic fragments consisting of basalt, dacite, minor pumice. Quartzite pebbles (up to 12 mm) also present. Note: The quartzite pebbles suggest contamination of this sample interval by base-course gravel used in drill pad construction. The presumed foreign material was likely introduced to the bottom (i.e., 40 ft bgs) of the open borehole during installation of the surface casing.

QBT 3 TSHIREGE MEMBER, BANDELIER TUFF: (44-49 ft) Volcanic tuff, light brownish gray (5YR 6/1), crystal-rich, phenocrysts (70% volume) of quartz and sanidine; lithic fragments common, mostly dacite with lesser basalt; rare pumice.

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REMEDIAL ACTIONS FOCUS AREA
BOREHOLE LOG

BOREHOLE ID: CdV-R37-2	TA/OU: TA-37	Page 2 of 22
DRILLING COMPANY: Tonto Drilling Co.	START DATE: July 2001	END DATE: August 2001
DRILLING EQ/METHOD: Foremost DR24		SAMPLING EQ/METHOD: Cuttings
GROUND ELEVATION: 7330.6' asl DRILLER: Thoren, Wilson, Woodward		TOTAL DEPTH = 1664' bgz GEOLOGY P.I.: Vaniman

Depth (ft)	Elevation (ft)	Core Run # (amt.-recov./amt. attemp.)	Core Run	Cuttings Collected	Geologic Characterization (Depth Interval)	Moisture/Matric Pot.	Lithology	Graphic Log	Lithologic Symbol
50	7280						QBT 3 TSHIREGE MEMBER, BANDELIER TUFF: (49-79 ft) Volcanic tuff, light gray (N7), crystal-rich, phenocrysts (40-80% volume) of quartz (pinkish, bi-pyramidal) and sanidine, abundant lithic fragments composed of dacite, minor basalt; rare pumice; partly welded. Drilling resistance increases at 50 feet bgs.		
55	7275								
60	7270								
65	7265								
70	7260								
75	7255								
80	7250						QBT 3 TSHIREGE MEMBER, BANDELIER TUFF: (79-104 ft) Volcanic tuff, light gray (N7), crystal-rich, non-welded; phenocrysts (40-80% volume) of pinkish quartz (bi-pyramidal crystals common) and sanidine crystals; minor small lithic fragments; pumice rare to absent.		
85	7245								
90	7240								Qbt3
95	7235								
100	7230								
105	7225						QBT 3 TSHIREGE MEMBER, BANDELIER TUFF: (104-139 ft) Volcanic tuff, light gray (N7), crystal-rich, lithic-poor. +10F (i.e., plus No. 10 sieve fraction): consists of quartz-sanidine crystals (up to 3 mm), euhedral to subhedral; fragments of welded tuff enclosing quartz-sanidine phenocrysts; minor lithic fragments of porphyritic andesite and basalt. +35F (plus No. 35 sieve fraction): dominantly quartz-sanidine crystals with 20-30% moderately welded tuff fragments.		
110	7220								
115	7215								
120	7210								
125	7205								
130	7200								
135	7195								

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BOREHOLE LOG

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DRILLING COMPANY: Tonto Drilling Co.	START DATE: July 2001	END DATE: August 2001
DRILLING EQ/METHOD: Foremost DR24		SAMPLING EQ/METHOD: Cuttings
GROUND ELEVATION: 7330.6' asl DRILLER: Thoren, Wilson, Woodward		TOTAL DEPTH = 1664' bgz GEOLOGY P.I.: Vaniman

Depth (ft)	Elevation (ft)	Core Run # (amt.-recov./amt. attemp.)	Core Run	Cuttings Collected	Geologic Characterization (Depth Interval)	Moisture/Matric Pot.	Lithology	Graphic Log	Lithologic Symbol
140	7190						QBT 3 TSHIREGE MEMBER, BANDELIER TUFF: (139-144 ft) Volcanic tuff, light brownish gray (5YR 6/1), crystal-rich, non-welded. WR sample consists of fine-grained ash, small (<1 mm) phenocrysts of sanidine and lesser quartz; some pumice and lithic fragments.		
145	7185								
150	7180						QBT 3 TSHIREGE MEMBER, BANDELIER TUFF: (144-154 ft) Volcanic tuff, light brownish gray (5YR 6/1), crystal-rich, moderately welded. +10F: contains 40% phenocrysts of euhedral (bi-pyramidal common) pinkish quartz and sanidine, phenocrysts are commonly enclosed within welded tuff fragments; remainder is pumice and lithic fragments of dacite and minor basalt.		Qbt3
155	7175								
160	7170								
165	7165						QBT 3 TSHIREGE MEMBER, BANDELIER TUFF: (154-194 ft) Volcanic tuff, light brownish gray (5YR 6/1), crystal-rich, non-welded. WR (unsieved whole rock) sample contains up to 80% phenocrysts of euhedral pinkish quartz (bi-pyramidal common) and sanidine; few pumice fragments; lithic fragments of dacite and andesite are present.		
170	7160								
175	7155								
180	7150								
185	7145								Qbt3
190	7140								
195	7135						QBT 3 TSHIREGE MEMBER, BANDELIER TUFF: (194-209 ft) Volcanic tuff, pale yellowish brown (10YR 6/2), crystal-rich, non-welded. +10F: 80-90% phenocrysts (up to 2.5 mm) of euhedral (commonly bi-pyramidal) pinkish quartz and sanidine; 10-20% dacite-andesite lithic fragments. +35F: 90-95% quartz-sanidine crystals. WR sample contains 75% crystals in a matrix of ash and clay.		
200	7130								
205	7125								
210	7120						QBT 2 TSHIREGE MEMBER, BANDELIER TUFF: (209-234 ft) Volcanic tuff, light brownish gray (5YR 6/1), crystal-rich, strongly welded. +10F: 90% welded tuff fragments (up to 4 mm) consisting of euhedral quartz-sanidine phenocrysts in an earthy, undeformed, welded ash matrix, Fe-oxide (limonite) alteration of ferromagnesian minerals; 5-10% felsic (ft) Volcanic lithics. First appearance of densely welded tuff indicates contact with Qbt2.		
215	7115								
220	7110								Qbt2
225	7105								

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DRILLING COMPANY: Tonto Drilling Co.	START DATE: July 2001	END DATE: August 2001
DRILLING EQ/METHOD: Foremost DR24		SAMPLING EQ/METHOD: Cuttings
GROUND ELEVATION: 7330.6' asl DRILLER: Thoren, Wilson, Woodward		TOTAL DEPTH = 1664' bgz GEOLOGY P.I.: Vaniman

Depth (ft)	Elevation (ft)	Core Run # (amt.-recov./amt. attemp.)	Core Run	Cuttings Collected	Geologic Characterization (Depth Interval)	Moisture/Matric Pot.	Lithology	Graphic Log	Lithologic Symbol
230–234	7100–7096			Yes			QBT 2 TSHIREGE MEMBER, BANDELIER TUFF: (209-234 ft) Volcanic tuff, light brownish gray (5YR 6/1), crystal-rich, strongly welded. +10F: 90% welded tuff fragments (up to 4 mm) consisting of euhedral quartz-sanidine phenocrysts in an earthy, undeformed, welded ash matrix, Fe-oxide (limonite) alteration of ferromagnesian minerals; 5-10% felsic (ft) Volcanic lithics. First appearance of densely welded tuff indicates contact with Qbt2.		Qbt2
234–259	7096–7071			Yes			QBT 2 TSHIREGE MEMBER, BANDELIER TUFF: (234-259 ft) Volcanic tuff, light brownish gray (5YR 6/1), crystal-rich, strongly welded. +10F: 60% welded tuff fragments, earthy luster matrix; 20% subrounded quartz-sanidine crystals; 10-20% intermediate to felsic volcanic lithics. WR sample ash- and clay-rich.		Qbt2
259–279	7071–7051			Yes			QBT 2 TSHIREGE MEMBER, BANDELIER TUFF: (259-279 ft) Volcanic tuff, light brownish gray (5YR 6/1), crystal-rich, strongly welded. +10F: 80-90% quartz-sanidine-rich welded tuff fragments, 10-20% intermediate volcanic lithics. +35F: 60% welded tuff fragments, 40% quartz-sanidine crystals, broken to subrounded, grains commonly stained with Fe-oxide (limonite).		Qbt2
279–289	7051–7041			Yes			QBT 2 TSHIREGE MEMBER, BANDELIER TUFF: (279-289 ft) Volcanic tuff, light brownish gray (5YR 6/1), crystal-rich, strongly welded. +10F/+35F: 80-90% welded tuff fragments, crystal-rich; 10-20% intermediate volcanic lithic fragments.		Qbt2
289–299	7041–7031			Yes			QBT 2 TSHIREGE MEMBER, BANDELIER TUFF: (289-299 ft) Volcanic tuff, light brownish gray (5YR 6/1), crystal-rich, strongly welded. +10F: 50% welded tuff fragments containing quartz, sanidine, and lithics; 30% liberated quartz-sanidine crystals; 20% intermediate to felsic volcanic lithics, including conspicuous biotite-hornblende-feldpar porphyry.		Qbt2
299–319	7031–7011			Yes			QBT 2 TSHIREGE MEMBER, BANDELIER TUFF: (299-319 ft) Volcanic tuff, light brownish gray (5YR 6/1), crystal-rich, strongly welded. +10F/+35F: 60% welded tufff fragments, 20% quartz-sanidine crystals, 20% intermediate volcanic lithic fragments.		Qbt2

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BOREHOLE LOG

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DRILLING COMPANY: Tonto Drilling Co.	START DATE: July 2001	END DATE: August 2001
DRILLING EQ/METHOD: Foremost DR24		SAMPLING EQ/METHOD: Cuttings
GROUND ELEVATION: 7330.6' asl DRILLER: Thoren, Wilson, Woodward		TOTAL DEPTH = 1664' bgz GEOLOGY P.I.: Vaniman

Depth (ft)	Elevation (ft)
320	7010
325	7005
330	7000
335	6995
340	6990
345	6985
350	6980
355	6975
360	6970
365	6965
370	6960
375	6955
380	6950
385	6945

Core Run # (amt.-recov./amt. attemp.)	Core Run	Cuttings Collected	Geologic Characterization (Depth Interval)	Moisture/Matric Pot.	Lithology	Graphic Log	Lithologic Symbol
		320–387 ft			QBT 2 TSHIREGE MEMBER, BANDELIER TUFF: (319-329 ft) Volcanic tuff, light brownish gray (5YR 6/1), crystal-rich, strongly welded. +10F: 70-80% crystal tuff fragments, strongly welded; 20% volcanic lithics of intermediate to felsic composition, including biotite-hornblende-felspar porphyry; 10% sanidine-quartz crystals.		Qbt2
					QBT 2 TSHIREGE MEMBER, BANDELIER TUFF: (329-339 ft) Volcanic tuff, light brownish gray (5YR 6/1), crystal-rich, partly welded. +10F: 40-50% crystals of euhedral quartz and sanidine (up to 2.5 mm); 30-40% non-vitric pumice with relict fibrous, frothy structure, some welded tuff fragments indicate partial moderate to strong welding; 5-10% volcanic lithics, including biotite-hornblende-feldspar porphyry.		
					QBT 2 TSHIREGE MEMBER, BANDELIER TUFF: (339-369 ft) Volcanic tuff, grayish orange-pink (5YR 7/2), non-welded. +10F: 80-90% phenocrysts of euhedral quartz and sanidine; 5-10% dacite-andesite lithic fragments; 5-10% welded tuff fragments. WR sample contains virtually no ash matrix.		
					QBT 2 TSHIREGE MEMBER, BANDELIER TUFF: (369-379 ft) Volcanic tuff, grayish orange-pink (5YR 7/2), non-welded. +10F: 60-70% euhedral quartz-sanidine crystals, commonly coated with white clay; 10-15% dacite-andesite lithic fragments; 10-20% white, punky, non-vitric pumice fragments, earthy luster.		
					QBT 2 TSHIREGE MEMBER, BANDELIER TUFF: (379-389 ft) Volcanic tuff, light pinkish gray (5YR 7/2), crystal-rich, lithic-poor, poorly welded to non-welded. +10F: (<10% of sample retained by No. 10 sieve) 85% dacite, rhyodacite lithics; 10% crystals, 5% pumice. WR sample 80-90% quartz-sanidine crystals, commonly stained with Fe-oxides 5-10% volcanic lithics; 2-5% pumice (no matrix present, indicating weak welding or none at all).		

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DRILLING COMPANY: Tonto Drilling Co.	START DATE: July 2001	END DATE: August 2001
DRILLING EQ/METHOD: Foremost DR24		SAMPLING EQ/METHOD: Cuttings
GROUND ELEVATION: 7330.6' asl DRILLER: Thoren, Wilson, Woodward		TOTAL DEPTH = 1664' bgz GEOLOGY P.I.: Vaniman

Depth (ft)	Elevation (ft)	Core Run # (amt.-recov./amt. attemp.)	Core Run	Cuttings Collected	Geologic Characterization (Depth Interval)	Moisture/Matric Pot.	Lithology	Graphic Log	Lithologic Symbol
390	6940						QBT 2 TSHIREGE MEMBER, BANDELIER TUFF: (389-399 ft) Volcanic tuff, light pinkish gray (5YR 7/2), crystal-rich, lithic-poor, poorly welded to non-welded. +10F: (<5% of sample retained by No. 10 sieve) 50-60% andesite, rhyodacite, dacite lithic fragments; 30-40% sanidine-sanidine crystals. WR sample: 60-70% crystals; 20-30% (ft) Volcanic ash; 5-10% volcanic lithics; no ash matrix.		Qbt2
395	6935								
400	6930						QBT 1V TSHIREGE MEMBER, BANDELIER TUFF: (399-404 ft) Volcanic tuff, orange-pink (5YR 7/2), crystal-rich, lithic-poor, non-welded. +10F: none of the sample retained on the No. 10 sieve. +35F/+60F: 90-95% quartz-sanidine crystals, 2-5% gray dacite and black vitrophyre.		Qbt1v
405	6925						QBT 1V TSHIREGE MEMBER, BANDELIER TUFF: (404-414 ft) Volcanic tuff, orange-pink (5YR /72), crystal-rich, non-welded. +10F: 95-97% volcanic lithic fragments, hornblende-dacite to rhyolite in composition. +35F: 85-90% quartz and sanidine crystals.		
410	6920								
415	6915				Geologic (414-419 ft)		QBT 1V TSHIREGE MEMBER, BANDELIER TUFF: (414-424 ft) Volcanic tuff, light pinkish gray (5YR 7/2), crystal-rich. +10F: 70% volcanic lithics (dacite, rhyodacite, minor vitrophyre); 30% fragments/clots of brown clay-cemented quartz-sanidine-lithics, locally limonite-stained; 10% liberated crystals. +35F: 98% quartz-sanidine crystals; 1-2% black vitrophyre.		
420	6910								
425	6905						QBT 1G TSHIREGE MEMBER, BANDELIER TUFF: (424-429 ft) Volcanic tuff, light pinkish gray (5YR 7/2), crystal-rich, pumice-rich, weakly welded. +10F: 60-70% white vitric pumice fragments, 30-40% dacite porphyry lithics and minor fragments of welded tuff. WR sample has clayey ash matrix.		Qbt1g
430	6900						QBT 1G TSHIREGE MEMBER, BANDELIER TUFF: (429-444 ft) Volcanic tuff light grayish pink (5YR 7/2), crystal-rich, weakly welded. +10F: 80-90% dacite to rhyolite lithics and minor fragments made up of crystals cemented by limonite; 10-20% crystals and minor pumice. +35F: 97% quartz and sanidine crystals, commonly Fe-oxide (limonite) stained. WR sample has clayey ash matrix.		
435	6895								
440	6890								

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BOREHOLE ID: CdV-R37-2	TA/OU: TA-37	Page 7 of 22
DRILLING COMPANY: Tonto Drilling Co.	START DATE: July 2001	END DATE: August 2001
DRILLING EQ/METHOD: Foremost DR24		SAMPLING EQ/METHOD: Cuttings
GROUND ELEVATION: 7330.6' asl DRILLER: Thoren, Wilson, Woodward		TOTAL DEPTH = 1664' bgz GEOLOGY P.I.: Vaniman

Depth (ft)	Elevation (ft)	Core Run # (amt.-recov./amt. attemp.)	Core Run	Cuttings Collected	Geologic Characterization (Depth Interval)	Moisture/Matric Pot.	Lithology	Graphic Log	Lithologic Symbol
445	6885						QBT 1G TSHIREGE MEMBER, BANDELIER TUFF: (444-449 ft) Volcanic tuff, light pinkish gray (5YR 7/2), crystal-rich, lithic-poor, pumice-rich. +10F: very minor quantity (<1%) retained on No.10 sieve. +35F: contains quartz and sanidine crystals and abundant pumice fragments. WR sample has clayey ash matrix.		Qbt1g
450	6880						QBT 1G TSHIREGE MEMBER, BANDELIER TUFF: (449-469 ft) Volcanic tuff, light pinkish gray (5YR 7/2), crystal-rich, lithic-rich poorly welded. +10F: 95% volcanic lithic fragments (andesite, dacite); 2-5% crystals and minor pumice. +35F: 100% quartz and sanidine crystals.		
455	6875								
460	6870								
465	6865								
470	6860						QBT 1G TSHIREGE MEMBER, BANDELIER TUFF: (469-479 ft) Volcanic tuff, light pinkish gray (5YR 7/2), crystal-rich, poorly welded. +10F: 95-985 dacite, rhyodacite rhyolite lithic fragments, 2-5% pumice and quartz-sanidine crystals. WR sample has clayey ash matrix.		
475	6855								
480	6850						QBT 1G TSHIREGE MEMBER, BANDELIER TUFF: (479-484 ft) Volcanic tuff, light pinkish gray (5YR 7/2), crystal-rich, pumice-rich, non-welded. +10F: 50% clay-cemented fragments (i.e., pumice, crystals, and lithics in a clay-cemented matrix), 40% white vitric pumice, 10% dacite lithics.		
485	6845						CERRO TOLEDO INTERVAL: (484-489 ft) Air-fall tuff/tuffaceous sediments, pale yellowish gray (5YR 8/1), lithic-rich, pumice-rich, non-welded. +10F:60% volcanic lithics (dacite rhyodacite, and minor vitrophyre), 35% white vitric pumice, 5% quartz-sanidine crystals. WR sample is clayey, ash-rich.		Qct
490	6840						CERRO TOLEDO INTERVAL: (489-519 ft) Air-fall tuff/tuffaceous sediments, pale gray (N7), crystal-rich, lithic-rich, non-welded. +10F: 80-95% volcanic lithics (andesite, dacite, flow-banded rhyodacite, minor basalt), 5-15% vitric pumice. +35F: relatively equal amounts of quartz, sanidine crystals and lithic fragments. WR sample clayey ash matrix.		
495	6835								
500	6830								
505	6825								
510	6820								
515	6815								
520	6810						CERRO TOLEDO INTERVAL: (519-534 ft) Air-fall tuff/tuffaceous sediments, mottled to medium gray (N5), lithic-rich, locally pumiceous, non-welded. +10F: 85-95% volcanic lithics (andesite, dacite, rhyodacite), 10-15% vitric pumice, commonly rounded fragments. +35F: 50% pumice, 30% lithics, 20% quartz-sanidine crystals.		
525	6805								
530	6800								

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REMEDIAL ACTIONS FOCUS AREA
BOREHOLE LOG

BOREHOLE ID: CdV-R37-2	TA/OU: TA-37	Page 8 of 22
DRILLING COMPANY: Tonto Drilling Co.	START DATE: July 2001	END DATE: August 2001
DRILLING EQ/METHOD: Foremost DR24		SAMPLING EQ/METHOD: Cuttings
GROUND ELEVATION: 7330.6' asl DRILLER: Thoren, Wilson, Woodward		TOTAL DEPTH = 1664' bgz GEOLOGY P.I.: Vaniman

Depth (ft)	Elevation (ft)	Core Run # (amt.-recov./amt. attemp.)	Core Run	Cuttings Collected	Geologic Characterization (Depth Interval)	Moisture/Matric Pot.	Lithology	Graphic Log	Lithologic Symbol
535	6795						CERRO TOLEDO INTERVAL: (534-544 ft) Air-fall tuff/tuffaceous sediments, medium gray (N5), lithic-rich, non-welded. +10F: 70-80% volcanic lithics (andesite, dacite, rhyodacite, vitrophyre), subrounded clasts common; 20-30% vitric pumice, frothy, rounded. +35F: 60-75% lithics, 25-40% quartz-sanidine crystals.		Qct
540	6790								
545	6785						CERRO TOLEDO INTERVAL: (544-549 ft) Air-fall tuff/tuffaceous sediments, mottled to medium gray (N5), lithic-rich, pumice-rich, non-welded. +10F: 50% volcanic lithic fragments (andesite, dacite, rhyodacite, minor vitrophyre), 50% vitric pumice fragments, rounded.		
550	6780						OTOWI MEMBER, BANDELIER TUFF: (549-564 ft) Volcanic tuff, orange- to pinkish tan (5YR 6/4), pumice-rich, poorly welded to non-welded. +10F: 60-90% pumice 10-40% volcanic lithics (andesite, dacite). +35F: pumice, lithics, and quartz-sanidine crystals in roughly equal percentages; pumices pinkish tan in color with earthy luster, as distinct from the white color and vitreous luster of pumices in Qct.		Qbo
555	6775								
560	6770								
565	6765						OTOWI MEMBER, BANDELIER TUFF: (564-579 ft) Volcanic tuff, pink tan (5YR 6/4), pumice-rich, poorly welded to non-welded. +10F: 100% pumice fragments that are rounded/subrounded (i.e., milled by drilling). +35F: dominance of pumice fragments; <10% lithic fragments and quartz, sanidine crystals.		
570	6760								
575	6755								
580	6750						OTOWI MEMBER, BANDELIER TUFF: (579-584 ft) Volcanic tuff, pinkish grayish tan (5YR 7/2), pumice-rich, lithic-rich, poorly welded to non-welded. +10F: roughly equal percentages of volcanic lithic fragments (andesite, dacite) and pumice. +35F: of similar makeup to +10F but also has 10-20% quartz-sanidine crystals.		
585	6745						OTOWI MEMBER, BANDELIER TUFF: (584-604 ft) Volcanic tuff, light pinkish brown (5YR 6/4), pumice-rich, lithic-poor, crystal-poor, poorly welded to non-welded. 90-99% of sample is pink-brown pumice fragments, no welded matrix present.		
590	6740								
595	6735								
600	6730								
605	6725						OTOWI MEMBER, BANDELIER TUFF: (604-624 ft) Volcanic tuff, light pinkish tan (5YR 6/4), pumice-rich, lithic-poor, crystal-poor, poorly welded to non-welded. +10F: 90-99% of sample is pumice fragments. +35F: 75-90% pumice, 10-25% crystals and volcanic lithic fragments.		
610	6720								
615	6715								
620	6710								

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BOREHOLE ID: CdV-R37-2	TA/OU: TA-37	Page 9 of 22
DRILLING COMPANY: Tonto Drilling Co.	START DATE: July 2001	END DATE: August 2001
DRILLING EQ/METHOD: Foremost DR24		SAMPLING EQ/METHOD: Cuttings
GROUND ELEVATION: 7330.6' asl DRILLER: Thoren, Wilson, Woodward		TOTAL DEPTH = 1664' bgz GEOLOGY P.I.: Vaniman

Depth (ft)	Elevation (ft)	Core Run # (amt.-recov./amt. attemp.)	Core Run	Cuttings Collected	Geologic Characterization (Depth Interval)	Moisture/Matric Pot.	Lithology	Graphic Log	Lithologic Symbol
625	6705						OTOWI MEMBER, BANDELIER TUFF: (624-629 ft) Volcanic tuff, light pinkish tan (5YR 6/4), pumice-rich, lithic-rich, poorly welded to non-welded. +10F: 90% pumice, 10% volcanic lithics. +35F: 90% lithic fragments, 10% pumice.		
630	6700						OTOWI MEMBER, BANDELIER TUFF: (629-639 ft) Volcanic tuff, light pinkish tan (5YR 7/2), pumice-rich, lithic-poor, crystal-poor, poorly welded to non-welded. 90-99% of sample made up of pumice fragments.		
635	6695								
640	6690						OTOWI MEMBER, BANDELIER TUFF: (639-649 ft) Volcanic tuff, light grayish brown (5YR 6/1), pumice-rich, lithic-rich, poorly welded to non-welded. +10F: pumice and volcanic (andesite, dacite) lithic fragments. +35F: volcanic lithics, quartz-sanidine crystals, and pumice in roughly equal percentages.		
645	6685								
650	6680						OTOWI MEMBER, BANDELIER TUFF: (649-654 ft) Volcanic tuff, pale orange-pink (5YR 8/4), lithic-rich, poorly welded to non-welded. +10F: <5% of sample retained on No. 10 sieve; composed mainly of volcanic lithics. +35F: lithic fragments and quartz-sanidine crystals in equal proportions. Whole rock sample has abundant clay/ash in matrix.		Qbo
655	6675						OTOWI MEMBER, BANDELIER TUFF: (654-669 ft) Volcanic tuff, pinkish (5YR 8/4) to mottled light gray (N7), lithic-rich, pumice-rich, poorly welded to non-welded. +10F: mainly pumice, becoming more lithic-rich downward in the interval. +35F: contains pumice, volcanic lithics, and quartz-sanidine crystals.		
660	6670								
665	6665								
670	6660						OTOWI MEMBER, BANDELIER TUFF: (669-689 ft) Volcanic tuff, pale yellowish brown (10YR 6/2), lithic-rich, pumice-rich, poorly welded to non-welded. +10F: mostly pumice becoming more lithic-rich downward in the interval; brown clay cementing some fragments. +35F: pumice, lithics, and quartz-sanidine crystals.		
675	6655				Geologic (669-684 ft)				
680	6650								
685	6645								
690	6640						OTOWI MEMBER, BANDELIER TUFF: (689-699 ft) Volcanic tuff, pale yellowish brown (10YR 6/2), pumice-rich, crystal-rich, lithic-poor, poorly welded to non-welded. +10F: pumice and minor volcanic lithic fragments. +35F: pumice and quartz-sanidine crystals.		
695	6635								

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BOREHOLE LOG

BOREHOLE ID: CdV-R37-2	TA/OU: TA-37	Page 10 of 22
DRILLING COMPANY: Tonto Drilling Co.	START DATE: July 2001	END DATE: August 2001
DRILLING EQ/METHOD: Foremost DR24		SAMPLING EQ/METHOD: Cuttings
GROUND ELEVATION: 7330.6' asl DRILLER: Thoren, Wilson, Woodward		TOTAL DEPTH = 1664' bgz GEOLOGY P.I.: Vaniman

Depth (ft)	Elevation (ft)	Core Run # (amt.-recov./amt. attemp.)	Core Run	Cuttings Collected	Geologic Characterization (Depth Interval)	Moisture/Matric Pot.	Lithology	Graphic Log	Lithologic Symbol
700	6630						OTOWI MEMBER, BANDELIER TUFF: (699-709 ft) Volcanic tuff, pale yellowish brown (10YR 6/2), lithic-rich, pumice-rich, poorly welded to non-welded. +10F: pumice and volcanic lithics; lithics decreasing in abundance downward in the interval. +35F: pumice, lithics and quartz-sanidine crystals in nearly equal proportion; percentage of pumice increases downward.		
705	6625								
710	6620						OTOWI MEMBER, BANDELIER TUFF: (709-724 ft) Volcanic tuff, pale yellowish brown (10YR 6/2), lithic-poor, pumice-rich, poorly welded to non-welded. +10F: mostly pumice with minor amounts of crystals and lithics. +35F: predominantly pumice.		
715	6615								
720	6610								
725	6605						OTOWI MEMBER, BANDELIER TUFF: (724-734 ft) Volcanic tuff, pinkish gray (5YR 8/1), pumice-rich, poorly welded to non-welded. +10F: angular to rounded pumice fragments. +35F: 90% pumice, 10% lithics and quartz-sanidine crystals.		
730	6600								Qbo
735	6595						OTOWI MEMBER, BANDELIER TUFF: (734-744 ft) Volcanic tuff, pinkish gray (5YR 7/2), crystal-rich, pumice-rich, poorly welded to non-welded. +10F: <1% of sample retained by No. 10 sieve. +35F: 40-45% pumice, 40-45%, quartz-sanidine crystals, 10-15% lithics of intermediate volcanic composition.		
740	6590								
745	6585						OTOWI MEMBER, BANDELIER TUFF: (744-754 ft) Volcanic tuff, light pinkish gray (5YR 7/2), lithic-rich, pumice-rich, poorly welded to non-welded. +10F: 35-45% banded rhyodacite, dacite,and andesite lithic fragments; 55-65% earthy pumice. WR sample has clayey ash matrix.		
750	6580								
755	6575						OTOWI MEMBER, BANDELIER TUFF: (754-759 ft) Volcanic tuff, light pinkish gray (5YR 7/2), lithic-rich, pumice-rich, poorly welded to non-welded. +10F: 55-65% earthy to vitric pumice, 35-45% rhyodacite, dacite, and andesite lithic fragments.		
760	6570						OTOWI MEMBER, BANDELIER TUFF: (759-764 ft) Volcanic tuff, light pinkish gray (5YR 7/2), lithic-poor, pumice-rich, poorly welded to non-welded. +10F: 99% frothy vitric pumice fragments. +35F: 95% pumice, 5% quartz-sanidine crystals.		

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DRILLING COMPANY: Tonto Drilling Co.	START DATE: July 2001	END DATE: August 2001
DRILLING EQ/METHOD: Foremost DR24		SAMPLING EQ/METHOD: Cuttings
GROUND ELEVATION: 7330.6' asl DRILLER: Thoren, Wilson, Woodward		TOTAL DEPTH = 1664' bgz GEOLOGY P.I.: Vaniman

Depth (ft)	Elevation (ft)	Core Run # (amt.-recov./amt. attemp.)	Core Run	Cuttings Collected	Geologic Characterization (Depth Interval)	Moisture/Matric Pot.	Lithology	Graphic Log	Lithologic Symbol
765	6565						OTOWI MEMBER, BANDELIER TUFF: (764-769 ft) Volcanic tuff, light pinkish gray (5YR 8/1), lithic-rich, pumice-rich, poorly welded to non-welded. +10F: 70-75 pumice, vitric, frothy; 25-30% volcanic (dacite, rhyodacite) lithics.		
770	6560						OTOWI MEMBER, BANDELIER TUFF: (769-774 ft) Volcanic tuff, light pinkish gray (5YR 8/1), lithic-rich, pumice-rich, poorly welded to non-welded. +10F: 75-85% volcanic lithic fragments (rhyodacite, dacite, andesite), 15-25% vitric pumice. +35F: 30-40% quartz-sanidine crystals, 40-50% pumice, 10-15% lithics.		
775	6555						OTOWI MEMBER, BANDELIER TUFF: (774-779 ft) Volcanic tuff, light pinkish gray (5YR 8/1), pumice-rich, poorly welded to non-welded. +10F: 85-90% vitric pumice, 0-15% rhyodacite lithics. +35F: 60% pumice, 30% quartz-sanidine crystals, 10% lithics.		
780	6550						OTOWI MEMBER, BANDELIER TUFF: (779-784 ft) Volcanic tuff, light pinkish gray (5YR 8/1), lithic-rich, poorly welded to non-welded. +10F: 85-90% volcanic (dacite, rhyodacite, rhyolite), 10-15% vitric pumice. WR sample has clayey matrix.		
785	6545						OTOWI MEMBER, BANDELIER TUFF: (784-789 ft) Volcanic tuff, varicolored to light pinkish gray (5YR 8/1), lithic-rich, pumice-rich, non-welded. +10F: 60-70% volcanic (andesite, dacite) lithic fragments, 30-40% white to pink-orange vitric pumice. +35F: 75-85% pumice, 15-25% lithics.		Qbo
790	6540						OTOWI MEMBER, BANDELIER TUFF: (789-794 ft) Volcanic tuff, varicolored to light pinkish gray (5YR 8/1) pumice-rich, non-welded. +10F: 75-85% white vitric pumice. 15-25% volcanic (andesite, dacite, rhyodacite) lithic fragments.		
795	6535				Geologic (795-810 ft)		OTOWI MEMBER, BANDELIER TUFF: (794-795 ft) No sample recovery.		
800	6530						OTOWI MEMBER, BANDELIER TUFF: (795-805 ft) Volcanic tuff, pale tan (5YR 5/6), lithic-rich, poorly welded to non-welded. +10F: composed of volcanic (andesite, dacite) lithics, pumice, and quartz-sanidine crystals; locally clasts are weakly cemented with Fe-oxides (limonite) and brown clay.		
805									

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DRILLING COMPANY: Tonto Drilling Co.	START DATE: July 2001	END DATE: August 2001
DRILLING EQ/METHOD: Foremost DR24		SAMPLING EQ/METHOD: Cuttings
GROUND ELEVATION: 7330.6' asl DRILLER: Thoren, Wilson, Woodward		TOTAL DEPTH = 1664' bgz GEOLOGY P.I.: Vaniman

Depth (ft)	Elevation (ft)
805	6525
810	6520
815	6515
820	6510
825	6505
830	6500
835	6495
840	6490
845	6485
850	6480
855	6475
860	6470
865	6465
870	6460
875	6455
880	6450
885	6445
890	6440

Core Run # (amt.-recov./amt. attemp.)	Core Run	Cuttings Collected	Geologic Characterization (Depth Interval)	Moisture/Matric Pot.	Lithology	Graphic Log	Lithologic Symbol
					OTOWI MEMBER, BANDELIER TUFF: (805-827 ft) Volcanic tuff, varicolored to light gray (N7). +10F: composed of intermediate and felsic volcanics (up to 15 mm), pumice, and quartz-sanidine crystals. +35F: lithics, pumice, and crystals; local limonitic clay-cemented clasts.		Qbo
					OTOWI MEMBER, BANDELIER TUFF: (827-837 ft) Volcanic tuff, varicolored to light gray (N7). +10F: composed of intermediate to felsic volcanic rocks, pumice and quartz-sanidine crystals.		Qbo
					OTOWI MEMBER, BANDELIER TUFF: (837-847 ft) Volcanic tuff, yellowish gray (5YR 8/1). +10-F: composed of intermediate to felsic volcanic rocks, pumice, and quartz-sanidine crystals; fragments locally composed of clay-cemented lithics and crystals.		Qbo
					OTOWI MEMBER, BANDELIER TUFF: (847-862 ft) Volcanic tuff, yellowish gray (5YR 8/1). +10F: composed of volcanic rocks (andesite, dacite, rhyodacite), pumice, and quartz-sanidine crystals. WR sample has clayey matrix.		Qbo
					OTOWI MEMBER, BANDELIER TUFF: (862-877 ft) Volcanic tuff, varicolored, pumice-rich. +10F: mostly pumice (up to 15 mm), with lesser andesite-dacite clasts and quartz-sanidine crystals. WR sample has clayey matrix.		Qbo
					OTOWI MEMBER, BANDELIER TUFF: (877-887 ft) Volcanic tuff, pinkish gray (5YR 7/2). +10F: 90-95% (ft) Volcanic (dacite, rhyodacite,rhyolite) lithic fragments, 5% quartz-sanidine crystals and pumice. WR sample contains clay and/or volcanic ash as weak cementation.		Qbo
					GUAJE PUMICE BED: (887-892 ft) Air-fall tuff, pale yellowish gray (5YR8/1), pumice-rich, non-welded. WR/+10F: 65-75% white, vitric pumice, 25-35% dacite-rhyodacite lithic fragments, 2-3% crystals.		Qbo-g

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DRILLING COMPANY: Tonto Drilling Co.	START DATE: July 2001	END DATE: August 2001
DRILLING EQ/METHOD: Foremost DR24		SAMPLING EQ/METHOD: Cuttings
GROUND ELEVATION: 7330.6' asl DRILLER: Thoren, Wilson, Woodward		TOTAL DEPTH = 1664' bgz GEOLOGY P.I.: Vaniman

Depth (ft)	Elevation (ft)	Core Run # (amt.-recov./amt. attemp.)	Core Run	Cuttings Collected	Geologic Characterization (Depth Interval)	Moisture/Matric Pot.	Lithology	Graphic Log	Lithologic Symbol
895	6435						GUAJE PUMICE BED: (892-897 ft) Air-fall tuff, light yellowish gray (5YR 8/1), lithic-rich, pumiceous, non-welded. +10F: 55-65% volcanic (dacite rhyodacite, black porphyritic vitrophyre) lithics, 35-45% white vitric pumice.		Qbo-g
900	6430						GUAJE PUMICE BED: (897-902 ft) Air-fall tuff, light yellowish gray (5YR 8/1), pumice-rich, non-welded. +10F: 70-75% white vitric and orange-tan earthy pumice fragments, commonly rounded; 25-30% andesite-dacite lithics, 2-3% quartz-sanidine crystals. Weak local Fe-oxides staining clasts.		
905	6425								
910	6420				Geologic (907-912 ft)				
915	6415						PUYE FORMATION: (902-907 ft) Clastic sediments. Gravel (GW), medium gray (N4), broken to subrounded clasts (up to 3 mm). WR/+10F: 100% volcanic lithics (dacite, rhyodacite, porphyritic vitrophyre).		
920	6410								
925	6405						PUYE FORMATION: (907-922 ft) Clastic sediments. Gravel (GW), medium gray (N4), broken to subrounded clasts. WR/+10F: 100% volcanic lithics (dominantly hornblende-dacite porphyry, minor rhyodacite, black vitrophyre).		
930	6400								
935	6395						PUYE FORMATION: (922-932 ft) Clastic sediments. Gravel (GW), medium gray (N4), most clasts angular, some exhibit subrounding. Predominantly composed of gray to dark gray clasts (siliceous, hornblende-quartz-biotite dacite); minor latite; few quartzite clasts locally stained with Fe-oxide.		Tp
940	6390								
945	6385								
950	6380						PUYE FORMATION: (932-942 ft) Clastic sediments. Gravel (GW), medium to light gray (N6), predominantly angular clasts. Composed of siliceous porphyritic volcanic rock with plagioclase, hornblende, and quartz phenocrysts.		
955	6375								
960	6370						PUYE FORMATION: (942-947 ft) Clastic sediments. Gravel with sand (GW), light brownish gray (5YR 6/1), well rounded. +10F: intermediate volcanic clasts ranging in color from purplish gray to red brown; phenocrysts of hornblende, plagioclase, and biotite.		
965	6365						PUYE FORMATION: (947-967 ft) Clastic sediments. Gravel with sand (GW), light brownish gray (5YR 6/1), broken to subrounded clasts. +10F: 80-90% feldspar-hornblende porphyry with distinctive large (>5 mm), subhedral to resorbed plagioclase phenocrysts; 10-20% other volcanic clasts of intermediate to felsic composition.		

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BOREHOLE ID: CdV-R37-2	TA/OU: TA-37	Page 14 of 22
DRILLING COMPANY: Tonto Drilling Co.	START DATE: July 2001	END DATE: August 2001
DRILLING EQ/METHOD: Foremost DR24		SAMPLING EQ/METHOD: Cuttings
GROUND ELEVATION: 7330.6' asl DRILLER: Thoren, Wilson, Woodward		TOTAL DEPTH = 1664' bgz GEOLOGY P.I.: Vaniman

Depth (ft)	Elevation (ft)	Core Run # (amt.-recov./amt. attemp.)	Core Run	Cuttings Collected	Geologic Characterization (Depth Interval)	Moisture/Matric Pot.	Lithology	Graphic Log	Lithologic Symbol
970	6360				Geologic (967-972 ft)		PUYE FORMATION: (967-982 ft) Clastic sediments. Gravel with sand (GW), pale brownish gray (5YR 6/1), broken to subrounded clasts. +10F: 80-90% plagioclase-hornblende porphyry with distinctive resorbed plagioclase phenocrysts; 10-20% other volcanic clasts of intermediate composition.		
975	6355								
980	6350								
985	6345						PUYE FORMATION: (982-987 ft) Clastic sediments. Gravel with sand (GW) pale brownish gray (5YR 6/1). Generally similar to 967-982 ft, but containing 10% light pinkish tan (5YR 8/1) subrounded clasts of tuffaceous sandstone.		
990	6340						PUYE FORMATION: (987-992 ft) Clastic sediments. Gravel with sand (GW), brownish gray (5YR 6/1), clasts broken to subrounded. +10F: >95% Tschicoma porphyritic andesite or dacite.		
995	6335								
1000	6330						PUYE FORMATION: (992-1002 ft) Clastic sediments. Sand (SW), light gray to yellowish brown (5YR 6/1), fine to coarse sand. Clasts made up of a variety of intermediate to felsic volcanic rocks. WR sample Fe-oxide stained.		Tp
1005	6325								
1010	6320						PUYE FORMATION: (1002-1012 ft) Clastic sediments. Gravel with sand and clay (GW), light brownish gray (5YR 6/1), clasts (up to 15 mm) rounded to subrounded. +10F: composed of porphyritic andesite and dacite, minor fine-grained tuffaceous sandstone. WR sample has clayey matrix.		
1015	6315								
1020	6310								
1025	6305						PUYE FORMATION: (1012-1032 ft) Clastic sediments. Gravel with sand (GW), brownish gray (5YR 6/1), clasts subangular to subrounded. +10F: 80-90% feldspar-hornblende porphyry (i.e., Tschicoma dacite/andesite); 10-20% other intermediate to felsic volcanic rocks.		
1030	6300								
1035	6295						PUYE FORMATION: (1032-1042 ft) Clastic sediments. Gravel with sand (GW), light brownish gray (5YR 6/1), clasts broken to subrounded. +10F: 80-90% porphyritic dacite; 10-20% other intermediate volcanic rocks and black vitrophyre; limonite staining common.		
1040	6290								
1045	6285						PUYE FORMATION: (1042-1047 ft) Clastic sediments. Gravel with sand and silt (GW), light brownish gray (5YR 6/1), clasts broken to subrounded. +10F: 70-80% hornblende-dacite porphyry, 20-30% other silicic volcanic rocks, minor indurated sandstone. WR sample has silty matrix.		

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DRILLING COMPANY: Tonto Drilling Co.	START DATE: July 2001	END DATE: August 2001
DRILLING EQ/METHOD: Foremost DR24		SAMPLING EQ/METHOD: Cuttings
GROUND ELEVATION: 7330.6' asl DRILLER: Thoren, Wilson, Woodward		TOTAL DEPTH = 1664' bgz GEOLOGY P.I.: Vaniman

Depth (ft)	Elevation (ft)	Core Run # (amt.-recov./amt. attemp.)	Core Run	Cuttings Collected	Geologic Characterization (Depth Interval)	Moisture/Matric Pot.
1050	6280					
1055	6275					
1060	6270					
1065	6265				Geologic (1062-1067 ft)	
1070	6260					
1075	6255				Geologic (1072-1077 ft)	
1080	6250					
1085	6245					
1090	6240					
1095	6235					
1100	6230					
1105	6225					

Lithology

PUYE FORMATION: (1047-1052 ft) Clastic sediments. Silty gravel with sand (GM), light pinkish gray (5YR 7/2), broken to subrounded clasts. +10F: 70-80% porphyritic hornblende-dacite; 20-30% orange-tan indurated tuffaceous siltstone. WR sample is silty.

PUYE FORMATION: (1052-1057 ft) Clastic sediments. Gravel with sand (GW), light gray (N5), broken to subrounded clasts. +10F: 75-80% hornblende-dacite porphyry, 20-25% black porphyritic vitrophyre, other intermediate volcanic rocks.

PUYE FORMATION: (1057-1072 ft) Clastic sediments. Clayey gravel with sand (GC), light pinkish gray (5YR 7/2), broken to subrounded clasts. +10F: 50-60% hornblende-dacite; 20-40% light tan tuffaceous siltstone fragments, 5-20% black porphyritic vitrophyre. WR sample is clay-rich. Interval distinguished by abundant tuffaceous sandstone, local vitrophyre.

TSCHICOMA FORMATION: (1072-1077 ft) Dacite, medium gray (N6), broken fragments. WR/+10F: 98% plagioclase-hornblende-dacite with siliceous aphanitic groundmass, 2% indurated tuffaceous siltstone fragments.

TSCHICOMA FORMATION: (1077- 1082 ft) Dacite, medium gray (N6), broken fragments. WR/+10F: 100% plagioclase-hornblende-dacite with siliceous aphanitic groundmass.

TSCHICOMA FORMATION: (1082-1087ft) Dacite/clastic sediments, light pinkish gray (5YR 7/2), clasts broken or rounded. WR/+10F: 65-75% porphyritic hornblende-dacite; 25-35%pinkish tan (5YR 6/4) indurated tuffaceous siltstone.

TSCHICOMA FORMATION: (1087-1102 ft) Dacite, medium gray (N5), broken fragments, no evidence of rounding. WR/+10F: 95-98% hornblende-(ft) Dacite porphyritic with siliceous aphanitic groundmass; 2-5% tuffaceous sandstone clasts.

TSCHICOMA FORMATION: (1102-1107 ft) Dacite/clastic sediments, medium gray (N5), broken fragments, no evidence of rounding. WR/+10F: 80-90% porphyritic hornblende-dacite with siliceous aphanitic groundmass, 10-20% light tan tuffaceous siltstone clasts.

Graphic Log | Lithologic Symbol

Tp

Tt

LOS ALAMOS NATIONAL LABORATORY
ENVIRONMENTAL RESTORATION
REMEDIAL ACTIONS FOCUS AREA
BOREHOLE LOG

BOREHOLE ID: CdV-R37-2	TA/OU: TA-37	Page 16 of 22
DRILLING COMPANY: Tonto Drilling Co.	START DATE: July 2001	END DATE: August 2001
DRILLING EQ/METHOD: Foremost DR24		SAMPLING EQ/METHOD: Cuttings
GROUND ELEVATION: 7330.6' asl DRILLER: Thoren, Wilson, Woodward		TOTAL DEPTH = 1664' bgz GEOLOGY P.I.: Vaniman

Depth (ft)	Elevation (ft)	Core Run # (amt.-recov./amt. attemp.)	Core Run	Cuttings Collected	Geologic Characterization (Depth Interval)	Moisture/Matric Pot.	Lithology	Graphic Log	Lithologic Symbol
1110	6220						TSCHICOMA FORMATION: (1107-1132 ft) Dacite, medium gray (N5), broken fragments. WR/+10F: 97-98% feldspar-hornblende dacite with distinctive large (up to 5 mm) plagioclase phenocrysts that are subhedral to resorbed; siliceous aphanitic groundmass, weak sericitic alteration and bleaching of groundmass; 2-3% rounded tuffaceous siltstone fragments.		
1115	6215								
1120	6210								
1125	6205								
1130	6200								
1135	6195						TSCHICOMA FORMATION: (1132-1152 ft) Dacite medium gray (N5), broken fragments and rare rounded clasts. WR/+10F: 99% dacite porphyry as described @ 1107-1132 ft; rare felsic volcanic pebble @ 1147-1152 ft. Locally, the dacite groundmass in this interval is moderately bleached and sericitized).		
1140	6190								
1145	6185								
1150	6180								Tt
1155	6175						TSCHICOMA FORMATION: (1152-1162 ft) Dacite, medium gray (N5), WR/+10F: dacite porphyry with aphanitic groundmass; phenocrysts of resorbed plagioclase, euhedral hornblende, and pyroxene (augite); augite exhibits cumulophyric texture; groundmass sericitized.		
1160	6170								
1165	6165						TSCHICOMA FORMATION: (1162-1192 ft) Dacite, light gray (N6), broken fragments, no evidence of rounding. WR/+10F: dacite porphyry, generally as described @ 1152-1162 ft. This interval characterized by sericitized and locallly bleached groundmass indicating hydrothermal alteration; groundmass has a corroded, pitted appearance.		
1170	6160								
1175	6155								
1180	6150								
1185	6145								
1190	6140				Geologic (1187-1192 ft)				

LOS ALAMOS NATIONAL LABORATORY
ENVIRONMENTAL RESTORATION
REMEDIAL ACTIONS FOCUS AREA
BOREHOLE LOG

BOREHOLE ID: CdV-R37-2	TA/OU: TA-37	Page 17 of 22
DRILLING COMPANY: Tonto Drilling Co.	START DATE: July 2001	END DATE: August 2001
DRILLING EQ/METHOD: Foremost DR24		SAMPLING EQ/METHOD: Cuttings
GROUND ELEVATION: 7330.6' asl DRILLER: Thoren, Wilson, Woodward		TOTAL DEPTH = 1664' bgz GEOLOGY P.I.: Vaniman

Depth (ft)	Elevation (ft)	Core Run # (amt.-recov./amt. attemp.)	Core Run	Cuttings Collected	Geologic Characterization (Depth Interval)	Moisture/Matric Pot.	Lithology	Graphic Log	Lithologic Symbol
1195	6135						TSCHICOMA FORMATION: (1192-1207 ft) Dacite, light gray (N6). WR/+10F: 100% plagioclase-hornblende-pyroxene porphyry with aphanitic groundmass that is moderately to strongly sericitized; locally bleached and Fe-oxide-stained. Corroded augite phenocrysts, not observed upsection of 1192 ft, are prominent.		
1200	6130								
1205	6125								
1210	6120				Geologic (1207-1209 ft)		TSCHICOMA FORMATION: (1207-1214 ft) Dacite/clastic sediments, medium gray (N5), broken to locally subrounded clasts. +10F: 70-80% hornblende-pyroxene porphyry, 20-30% rounded clasts (up to 20 mm) of indurated tuffaceous siltstone.		
1215	6115								
1220	6110						TSCHICOMA FORMATION: (1214-1229 ft) Dacite, light gray (N6), broken fragments only. WR/+10F: 98% plagioclase-hornblende-pyroxene (augite) porphyry with aphanitic groundmass that is sericitized and locally bleached, 2% fragments of pinkish tan tuffaceous siltstone @ 1214-1219 ft.		
1225	6105								
1230	6100								Tt
1235	6095						TSCHICOMA FORMATION: (1229-1249 ft) Dacite, medium to light gray (N6), porphyritic with microcrystalline to vitric groundmass. WR/+10F: 100% plagioclase-hornblende-pyroxene dacite.		
1240	6090								
1245	6085								
1250	6080						TSCHICOMA FORMATION: (1249-1274 ft) Dacite light brownish gray (5YR 6/1), porphyritic with aphanitic groundmass. WR/+10F: 100% hornblende-pyroxene dacite groundmass strongly sericitized and bleached with corroded texture, ferromagnesian minerals commonly oxidized.		
1255	6075								
1260	6070								
1265	6065								
1270	6060								

LOS ALAMOS NATIONAL LABORATORY
ENVIRONMENTAL RESTORATION
REMEDIAL ACTIONS FOCUS AREA
BOREHOLE LOG

BOREHOLE ID: CdV-R37-2	TA/OU: TA-37	Page 18 of 22
DRILLING COMPANY: Tonto Drilling Co.	START DATE: July 2001	END DATE: August 2001
DRILLING EQ/METHOD: Foremost DR24		SAMPLING EQ/METHOD: Cuttings
GROUND ELEVATION: 7330.6' asl DRILLER: Thoren, Wilson, Woodward		TOTAL DEPTH = 1664' bgz GEOLOGY P.I.: Vaniman

Depth (ft)	Elevation (ft)	Core Run # (amt.-recov./amt. attemp.)	Core Run	Cuttings Collected	Geologic Characterization (Depth Interval)	Moisture/Matric Pot.	Lithology	Graphic Log	Lithologic Symbol
1275	6055						TSCHICOMA FORMATION: (1274-1309 ft) Dacite, light pinkish to brownish gray (5YR 6/1), porphyritic with microcrystalline groundmass. WR/+10F: 97-100% plagioclase-hornblende-pyroxene porphyry, mafic phenocrysts commonly oxidized, some phenocrysts have alteration rinds, locally 1-3% tuffaceous siltstone.		
1280	6050								
1285	6045								
1290	6040								
1295	6035								
1300	6030								
1305	6025								
1310	6020						TSCHICOMA FORMATION: (1309-1319 ft) Dacite, medium light gray (N6), angular porphyritic fragments, no evidence of rounding. WR/+10F: phenocrysts of plagioclase, hornblende, pyroxene, and sanidine in a microcrystalline groundmass. Many red-brown blocky masses (i.e., altered mafic phenocrysts); some phenocrysts have alteration rinds. Oxide coatings on fracture surfaces are common.		
1315	6015								
1320	6010						TSCHICOMA FORMATION: (1319-1324 ft) No sample recovery.		Tt
1325	6005						TSCHICOMA FORMATION: (1324-1354 ft) Dacite, light brownish gray (5YR 6/1) and medium gray (N5), angular porphyritic rock fragments. WR/+10F: Phenocrysts of plagioclase, hornblende, and pyroxene in a microcrystalline groundmass. Reddish brown rinds on mafic crystals common. Red-brown oxide coatings on fragments indicate fracturing and possible brecciation.		
1330	6000								
1335	5995								
1340	5990								
1345	5985								
1350	5980								

LOS ALAMOS NATIONAL LABORATORY
ENVIRONMENTAL RESTORATION
REMEDIAL ACTIONS FOCUS AREA
BOREHOLE LOG

BOREHOLE ID: CdV-R37-2	TA/OU: TA-37	Page 19 of 22
DRILLING COMPANY: Tonto Drilling Co.	START DATE: July 2001	END DATE: August 2001
DRILLING EQ/METHOD: Foremost DR24		SAMPLING EQ/METHOD: Cuttings
GROUND ELEVATION: 7330.6' asl DRILLER: Thoren, Wilson, Woodward		TOTAL DEPTH = 1664' bgz GEOLOGY P.I.: Vaniman

Depth (ft)	Elevation (ft)	Core Run # (amt.-recov./amt. attemp.)	Core Run	Cuttings Collected	Geologic Characterization (Depth Interval)	Moisture/Matric Pot.	Lithology	Graphic Log	Lithologic Symbol
1355	5975						TSCHICOMA FORMATION: (1354-1364 ft) Dacite, light brownish gray (5YR 6/1), porphyritic with microcrystalline groundmass. WR/+10F: 98-100% plagioclase-hornblende-pyroxene porphyry, groundmass sericitzed, bleached, vuggy; 1-2% tuffaceous siltstone fragments. WR sample has clay-s silty matrix. Fe-oxide coatings on some fragment surfaces suggest fractures and/or brecciation.		
1360	5970								
1365	5965						TSCHICOMA FORMATION: (1364-1379 ft) Dacite, light brownish gray (5YR 6/1), porphyritic with microcrystalline to vitric groundmass, broken fragments and subrounded clasts. WR/+10F: 97-98% plagioclase-hornblende-pyroxene (minor) porphyry, groundmass sericitized; 1-3% light tan clay fragments, waxy luster.		
1370	5960								
1375	5955								
1380	5950						TSCHICOMA FORMATION: (1379-1389 ft) Dacite/clastic sediments, medium to dark gray (N4), clasts broken to subrounded. +10F: 90-95% plagioclase-hornblende-pyroxene porphyry, aphanitic groundmass locally bleached/ 5-10% waxy clay. Clay present in WR sample @ 1384-1389 ft.		
1385	5945								
1390	5940				Geologic (1389-1394 ft)		TSCHICOMA FORMATION: (1389-1404 ft) Dacite/clastic sediments, medium gray (N5), clasts broken to subrounded. +10F: 75-95% plagioclase-hornblende-(minor) pyroxene porphyry with aphanitic groundmass that is locallly bleached, sericitized, 5-25% (increasing downward) light tan waxy clay. WR sample clayey.		
1395	5935								
1400	5930								Tt
1405	5925						TSCHICOMA FORMATION: (1404-1414 ft) Dacite/clastic sediments, medium to dark gray (N4) to light brownish gray (5YR 6/1), clasts broken or commonly subrounded. +10F: 50-65% plagioclase-hornblende porphyry with an aphanitic groundmass that is bleached, strongly sericitzed or argillized; 20-30% light tan tuffaceous siltstone, 10-25% waxy clay fragments.		
1410	5920								
1415	5915						TSCHICOMA FORMATION: (1414-1439 ft) Dacite, medium gray (N6), broken fragments, rarely subrounded, porphyritic with aphanitic groundmass. +10F: 95-98% plagioclase-hornblende porphyry, siliceous groundmass locally bleached; 2-3% orange-tan waxy clay particles present.		
1420	5910								
1425	5905								
1430	5900								
1435	5895								

LOS ALAMOS NATIONAL LABORATORY
ENVIRONMENTAL RESTORATION
REMEDIAL ACTIONS FOCUS AREA
BOREHOLE LOG

BOREHOLE ID: CdV-R37-2	TA/OU: TA-37	Page 20 of 22
DRILLING COMPANY: Tonto Drilling Co.	START DATE: July 2001	END DATE: August 2001
DRILLING EQ/METHOD: Foremost DR24		SAMPLING EQ/METHOD: Cuttings
GROUND ELEVATION: 7330.6' asl DRILLER: Thoren, Wilson, Woodward		TOTAL DEPTH = 1664' bgz GEOLOGY P.I.: Vaniman

Depth (ft)	Elevation (ft)	Core Run # (amt.-recov./amt. attemp.)	Core Run	Cuttings Collected	Geologic Characterization (Depth Interval)	Moisture/Matric Pot.	Lithology	Graphic Log	Lithologic Symbol
1440	5890						TSCHICOMA FORMATION: (1439-1469 ft) Dacite, medium gray (N6). +10F: Porphyritic rock with siliceous aphanitic groundmass; phenocrysts (30-40% vol.) of resorbed plagioclase, hornblende, and pyroxene. Rock is locally bleached and pitted by removal of altered feldspar crystals. Minor pale-tan colored clay fragments display waxy luster.		
1445	5885								
1450	5880								
1455	5875								
1460	5870								
1465	5865								
1470	5860						TSCHICOMA FORMATION: (1469-1489 ft) Dacite, medium to dark gray (N5). +10F: porphyritic with aphanitic groundmass; phenocrysts of resorbed plagioclase, euhedral pyroxene and hornblende. Rock moderately bleached/altered and has a pitted, corroded appearance. White clay fragments common @1474-1489 ft.		
1475	5855								
1480	5850								
1485	5845								Tt
1490	5840						TSCHICOMA FORMATION: (1489-1514 ft) Dacite, medium to dark gray (N5). WR/+10F: strongly porphyritic with aphanitic groundmass; phenocrysts (30-40% vol.) of plagioclase (resorbed, zoned, corroded), resorbed pyroxene, and euhedral hornblende. Weak alteration includes bleaching and Fe-oxide staining. Minor fragments of pinkish to white clay.		
1495	5835								
1500	5830								
1505	5825								
1510	5820								
1515	5815				Geologic (1514-1519 ft)		TSCHICOMA FORMATION: 1514-1529 ft) Dacite, varicolored, light gray (N7) to reddish orange (10YR 6/6). WR/+10F: porphyritic with altered aphanitic groundmass; phenocrysts of plagioclase, pyroxene, and hornblende. Rock is dominantly bleached or Fe-oxide-stained; groundmass is strongly sericitized to argillized, commonly pitted with a corroded appearance. Minor white, waxy-looking clay fragments.		
1520	5810								
1525	5805								

LOS ALAMOS NATIONAL LABORATORY
ENVIRONMENTAL RESTORATION
REMEDIAL ACTIONS FOCUS AREA
BOREHOLE LOG

BOREHOLE ID: CdV-R37-2	TA/OU: TA-37	Page 21 of 22
DRILLING COMPANY: Tonto Drilling Co.	START DATE: July 2001	END DATE: August 2001
DRILLING EQ/METHOD: Foremost DR24		SAMPLING EQ/METHOD: Cuttings
GROUND ELEVATION: 7330.6' asl DRILLER: Thoren, Wilson, Woodward		TOTAL DEPTH = 1664' bgz GEOLOGY P.I.: Vaniman

Depth (ft)	Elevation (ft)	Core Run # (amt.-recov./amt. attemp.)	Core Run	Cuttings Collected	Geologic Characterization (Depth Interval)	Moisture/Matric Pot.	Lithology	Graphic Log	Lithologic Symbol
1530–1549	5800–5785						TSCHICOMA FORMATION: (1529-1549 ft) Dacite, medium gray (N6) to reddish orange (10YR 6/6). WR/+10F: strongly porphyritic with altered aphanitic groundmass; phenocrysts (30-50% vol.) of resorbed plagioclase, resorbed pyroxene and euhedral hornblende. Groundmass locally bleached, sericitized, or pitted/corroded.		Tt
1550–1564	5780–5770						TSCHICOMA FORMATION: (1549-1564 ft) Dacite, light brownish gray (5YR 6/1). WR/+10F: porphyritic with aphanitic groundmass; phenocrysts of plagioclase, pyroxene and hornblende. Groundmass generally sericitized, bleached or pitted/corroded; locally Fe-oxide stained.		
1565–1584	5765–5750						TSCHICOMA FORMATION: (1564-1584 ft) Dacite, medium gray (N5). WR/+10F: porphyritic with siliceous aphanitic groundmass; phenocrysts of resorbed plagioclase, anhedral pyroxene and euhedral hornblende. Rock is locally bleached, sericitized or argillized.		

LOS ALAMOS NATIONAL LABORATORY
ENVIRONMENTAL RESTORATION
REMEDIAL ACTIONS FOCUS AREA
BOREHOLE LOG

BOREHOLE ID: CdV-R37-2	TA/OU: TA-37	Page 22 of 22
DRILLING COMPANY: Tonto Drilling Co.	START DATE: July 2001	END DATE: August 2001
DRILLING EQ/METHOD: Foremost DR24		SAMPLING EQ/METHOD: Cuttings
GROUND ELEVATION: 7330.6' asl DRILLER: Thoren, Wilson, Woodward		TOTAL DEPTH = 1664' bgz GEOLOGY P.I.: Vaniman

Depth (ft)	Elevation (ft)	Core Run # (amt.-recov./amt. attemp.)	Core Run	Cuttings Collected	Geologic Characterization (Depth Interval)	Moisture/Matric Pot.	Lithology	Graphic Log	Lithologic Symbol
1585–1614	5745–5716			X			TSCHICOMA FORMATION: (1584-1614 ft) Dacite light gray (N7). WR/+10F: porphyritic with aphanitic groundmass; phenocrysts of rounded (resorbed) plagioclase, resorbed pyroxene, and hornblende. This interval characterized by moderate to strong alteration; groundmass is generally sericitized to argillized and bleached; distinct Fe-oxide replacement of hornblende rims.		Tt
1614–1634	5716–5696			X			TSCHICOMA FORMATION: (1614-1634 ft) Dacite, varicolored, light (N8) to medium gray (N5). WR/+10F: porphyritic with siliceous aphanitic groundmass; phenocrysts of plagioclase, pyroxene, and hornblende. Roughly 50% of rock exhibits strong hydrothermal alteration; groundmass partly bleached and sericitzed.		Tt
1634–1664	5696–5666			X	Geologic (1654-1659 ft)		TSCHICOMA FORMATION: (1634-1664 ft) Dacite, light gray (N8) to medium gray (N5). WR/+10F: porphyritic with siliceous aphanitic groundmass; phenocrysts of resorbed and corroded plagioclase, euhedral hornblende with distinctive Fe-oxide rims, and pyroxene. Very strong hydrothermal alteration throughout the interval; groundmass sericitized and bleached.		Tt

Depth scale (ft): 1585, 1590, 1595, 1600, 1605, 1610, 1615, 1620, 1625, 1630, 1635, 1640, 1645, 1650, 1655, 1660, 1665, 1670
Elevation scale (ft): 5745, 5740, 5735, 5730, 5725, 5720, 5715, 5710, 5705, 5700, 5695, 5690, 5685, 5680, 5675, 5670, 5665

Appendix D

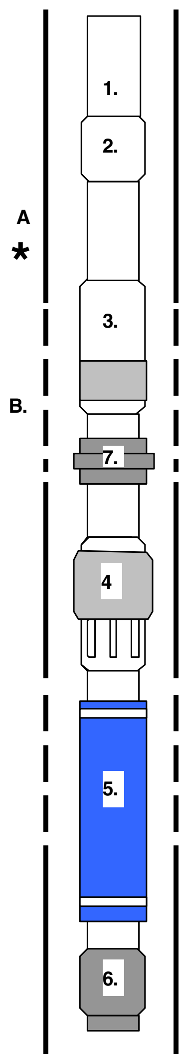
Westbay's MP55 Well Components Installed in CdV-R-37-2

Table 1. Summary of Packer Inflation Information, LANL Well CdV-R-37-2

Zone No.	Packer Serial No.	Packer No.	Date Inflated (2001)	Calculated Element Pressure (psi)	Inflation Volume (litres)	QA Test Passed
	0612-373	1	Oct. 8	264	2.5	Yes
LQA-1						
	0612-372	2	Oct. 8	269	2.4	Yes
LQA-2						
	0612-185	3	Oct. 8	238	2.6	Yes
SQA-1						
	0612-187	4	Oct. 7	230	2.5	Yes
Zone 1						
	0612-186	5	Oct. 7	260	2.3	Yes
LQA-3						
	0612-371	6	Oct. 7	237	2.75	Yes
SQA-2						
	0612-374	7	Oct. 7	278	2.5	Yes
Zone 2						
	0612-181	8	Oct. 7	250	2.4	Yes
LQA-4						
	0612-209	9	Oct. 7	164	2.5	Yes
SQA-3						
	0612-191	10	Oct. 7	193	2.4	Yes
Zone 3						
	0612-193	11	Oct. 7	215	2.5	Yes
LQA-5						
	0612-370	12	Oct. 7	224	2.5	Yes
SQA-4						
	0612-190	13	Oct. 6	178	2.5	Yes
Zone 4						
	0612-192	14	Oct. 2	84	2.5	Yes
SQA-5						

MP Drift Diagram

Job No. WB777	Monitoring Well No. CdV-R37-2	Drawn By: DL
Client: LANL	Project: Hydrogeology Investigation	Date: Sept 23, 2001
Drift Approval (See MP Casing Installation Log)	Borehole Items:	
	MP Casing Items:	



MP System Casing Components				
Item	Model No.	Description	I.D. (in)	O.D. (in)
1.	0601	MP55 Casing	2.25	2.87
2.	0602	MP55 Regular Coupling	2.25	3.6
3.	0605	MP55 Measurement Port Coupling	2.25	3.5
4.	0607	MP55 Hydraulic Pumping Port	2.25	3.5
5.	0612	MP55 Packer, with stiffeners	2.25	4.3
6.	0603	End Plug	2.25	3.6
7.	0608	Magnetic Location Collar	2.9	3.6
Borehole Completion Items				
A.	N/A	Stainless Steel Well Casing*	4.5*	5.0
B.	N/A	Stainless Steel Well Screens, 0.010 in. slot size, pipe-based type.	4.5	5.5

Notes:

1) Confirm that inside pipe joints are smooth. Confirm that the ID of each screen has been gauged and is smooth.

2) The sketches of MP casing components on this Drift Diagram are only to illustrate comparative dimensions. Please refer to the Proposed Casing Log for details on the proposed sequence of MP casing components in the well.

3) Nominal 'drift' for tools to run inside MP55 casing components = 50mm.

4) Well screens are SS ASTM A554 casing with ~3.16 inch diameter perforations drilled through the pipe wall and conventional wire wrap on outside of the pipe.

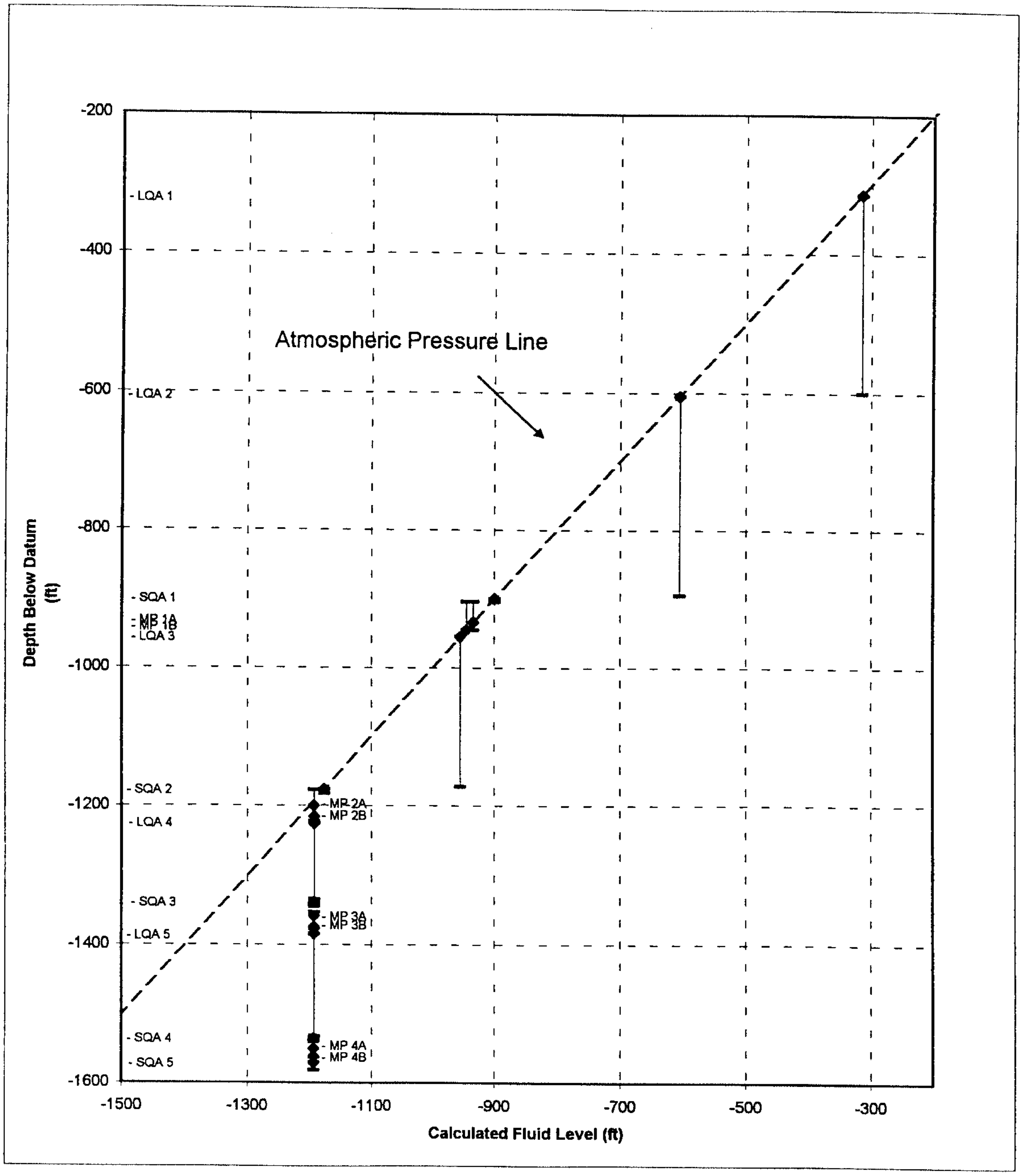
File: MP Drift CdV_R37_2.doc

DL, Westbay Instruments Inc. 2001

Figure 1

Piezometric Profile (Pre-Inflation)
Monitoring Well:
R-37

Profile Date: 10/01/01
Comments: All Zones
(Pre-Inflation)
G.L. Ref. Elev.: Ground



Client: Los Alamos National Lab
Site: LANL
Datum: Ground Level

Plot By:_______ Date:______
Checked By: ~~~ Date: 21 Nov 01
Westbay Project : WB777
File: Graph Chart 1

Figure 1 (continued)

MOSDAX Data Report
(c) WESTBAY INSTRUMENTS 1990-1991
Date Of Report: Mon Oct 22 09:18:42 2001

Company Name: LANL
Project Name: R_37-2 Pre-Inflation Profile
Well ID: CdV_R37-2
Well Description: Plastic MP-55
Well Elevation: 0.00 (ft)

Probe Information

Logical Probe-1 - Serial #: 2652 - Description: SAMPLER

Port Information

Port #:00 - Description	ATMOSPHERIC - Depth 0.0 (ft) - ACF	1.0
Port #:01 - Description	LQA-1 - Depth 314.6 (ft) - ACF	1.0
Port #:02 - Description	LQA-2 - Depth 604.7 (ft) - ACF	1.0
Port #:03 - Description	SQA-1 - Depth 900.1 (ft) - ACF	1.0
Port #:04 - Description	MP-1A - Depth 934.6 (ft) - ACF	1.0
Port #:05 - Description	MP-1B - Depth 945.6 (ft) - ACF	1.0
Port #:06 - Description	LQA-3 - Depth 955.6 (ft) - ACF	1.0
Port #:07 - Description	SQA-2 - Depth 1177.2 (ft) - ACF	1.0
Port #:08 - Description	MP-2A - Depth 1200.3 (ft) - ACF	1.0
Port #:09 - Description	MP-2B - Depth 1216.2 (ft) - ACF	1.0
Port #:10 - Description	LQA-4 - Depth 1226.18 (ft) - ACF	1.0
Port #:11 - Description	SQA-3 - Depth 1339.5 (ft) - ACF	1.0
Port #:12 - Description	MP-3A - Depth 1359.3 (ft) - ACF	1.0
Port #:13 - Description	MP-3B - Depth 1375.2 (ft) - ACF	1.0
Port #:14 - Description	LQA-5 - Depth 1385.2 (ft) - ACF	1.0
Port #:15 - Description	SQA-4 - Depth 1535.7 (ft) - ACF	1.0
Port #:16 - Description	MP-4A - Depth 1550.6 (ft) - ACF	1.0
Port #:17 - Description	MP-4B - Depth 1561.6 (ft) - ACF	1.0
Port #:18 - Description	SQA-5 - Depth 1571.6 (ft) - ACF	1.0

Figure 1 (continued)

TIME DATE	PORT NUMBER	PROBE NUMBER	PRES (psi)	ATMOS (psi)	RfPz'D (ft)	TEMP (C)	DEPTH (ft)	MOTOR POSITION
Mon Oct 01 13:38:13 2001	0	1	11.52	11.52	0.0	24.3	ATMOS	INSIDE (Home)
Mon Oct 01 14:07:38 2001	1	1	11.56	11.52	-314.5	23.3	314.6	INSIDE (Arm)
Mon Oct 01 14:08:35 2001	1	1	11.56	11.52	-314.5	23.1	314.6	OUTSIDE (Shoe)
Mon Oct 01 14:08:59 2001	1	1	11.50	11.52	-314.7	22.9	314.6	INSIDE (Arm)
Mon Oct 01 14:14:48 2001	2	1	11.58	11.52	-604.5	21.3	604.7	INSIDE (Arm)
Mon Oct 01 14:15:14 2001	2	1	11.57	11.52	-604.5	21.2	604.7	OUTSIDE (Shoe)
Mon Oct 01 14:15:41 2001	2	1	11.57	11.52	-604.6	21.1	604.7	INSIDE (Arm)
Mon Oct 01 15:48:42 2001	3	1	11.79	11.52	-899.4	20.4	900.1	INSIDE (Arm)
Mon Oct 01 15:49:09 2001	3	1	11.91	11.52	-899.2	20.4	900.1	OUTSIDE (Shoe)
Mon Oct 01 15:49:30 2001	3	1	11.85	11.52	-899.3	20.4	900.1	INSIDE (Arm)
Mon Oct 01 14:35:22 2001	4	1	11.81	11.52	-934.0	19.1	934.6	INSIDE (Arm)
Mon Oct 01 14:35:48 2001	4	1	11.87	11.52	-933.8	19.1	934.6	OUTSIDE (Shoe)
Mon Oct 01 14:36:09 2001	4	1	11.75	11.52	-934.1	19.1	934.6	INSIDE (Arm)
Mon Oct 01 14:39:28 2001	5	1	11.92	11.52	-944.7	19.0	945.6	INSIDE (Arm)
Mon Oct 01 14:39:47 2001	5	1	11.86	11.52	-944.9	19.0	945.6	OUTSIDE (Shoe)
Mon Oct 01 14:40:06 2001	5	1	11.86	11.52	-944.9	19.0	945.6	INSIDE (Arm)
Mon Oct 01 14:45:38 2001	6	1	11.86	11.52	-954.8	18.9	955.6	INSIDE (Arm)
Mon Oct 01 14:46:02 2001	6	1	11.92	11.52	-954.7	18.9	955.6	OUTSIDE (Shoe)
Mon Oct 01 14:46:15 2001	6	1	11.92	11.52	-954.7	18.9	955.6	INSIDE (Arm)
Mon Oct 01 14:52:44 2001	7	1	11.98	11.52	-1176.1	19.0	1177.2	INSIDE (Arm)
Mon Oct 01 14:53:03 2001	7	1	11.98	11.52	-1176.1	19.0	1177.2	OUTSIDE (Shoe)
Mon Oct 01 14:53:24 2001	7	1	11.86	11.52	-1176.4	19.0	1177.2	INSIDE (Arm)
Mon Oct 01 14:55:50 2001	8	1	11.87	11.52	-1199.5	19.1	1200.3	INSIDE (Arm)
Mon Oct 01 14:56:35 2001	8	1	15.02	11.52	-1192.2	19.1	1200.3	OUTSIDE (Shoe)
Mon Oct 01 14:57:11 2001	8	1	12.05	11.52	-1199.1	19.2	1200.3	INSIDE (Arm)
Mon Oct 01 14:59:31 2001	9	1	11.81	11.52	-1215.5	19.3	1216.2	INSIDE (Arm)
Mon Oct 01 15:00:20 2001	9	1	22.12	11.52	-1191.8	19.3	1216.2	OUTSIDE (Shoe)
Mon Oct 01 15:00:48 2001	9	1	12.00	11.52	-1215.1	19.4	1216.2	INSIDE (Arm)
Mon Oct 01 15:02:38 2001	10	1	12.00	11.52	-1338.4	19.4	1339.5	INSIDE (Arm)
Mon Oct 01 15:02:59 2001	10	1	26.42	11.52	-1305.1	19.5	1339.5	OUTSIDE (Shoe)
Mon Oct 01 15:03:17 2001	10	1	11.88	11.52	-1338.6	19.5	1339.5	INSIDE (Arm)
Mon Oct 01 15:05:57 2001	11	1	12.07	11.52	-1338.2	19.6	1339.5	INSIDE (Arm)
Mon Oct 01 15:06:41 2001	11	1	75.35	11.52	-1192.2	19.6	1339.5	OUTSIDE (Shoe)
Mon Oct 01 15:06:57 2001	11	1	11.95	11.52	-1338.5	19.6	1339.5	INSIDE (Arm)
Mon Oct 01 15:13:29 2001	12	1	12.08	11.52	-1358.0	19.9	1359.3	INSIDE (Arm)
Mon Oct 01 15:13:48 2001	12	1	83.81	11.52	-1192.5	20.0	1359.3	OUTSIDE (Shoe)
Mon Oct 01 15:14:19 2001	12	1	12.08	11.52	-1358.0	19.9	1359.3	INSIDE (Arm)
Mon Oct 01 15:17:14 2001	13	1	12.02	11.52	-1374.1	20.0	1375.2	INSIDE (Arm)
Mon Oct 01 15:17:35 2001	13	1	90.64	11.52	-1192.7	20.1	1375.2	OUTSIDE (Shoe)
Mon Oct 01 15:18:14 2001	13	1	12.08	11.52	-1373.9	20.1	1375.2	INSIDE (Arm)
Mon Oct 01 15:21:01 2001	14	1	12.02	11.52	-1384.0	20.1	1385.2	INSIDE (Arm)
Mon Oct 01 15:21:29 2001	14	1	95.11	11.52	-1192.3	20.2	1385.2	OUTSIDE (Shoe)
Mon Oct 01 15:21:52 2001	14	1	12.09	11.52	-1383.9	20.2	1385.2	INSIDE (Arm)

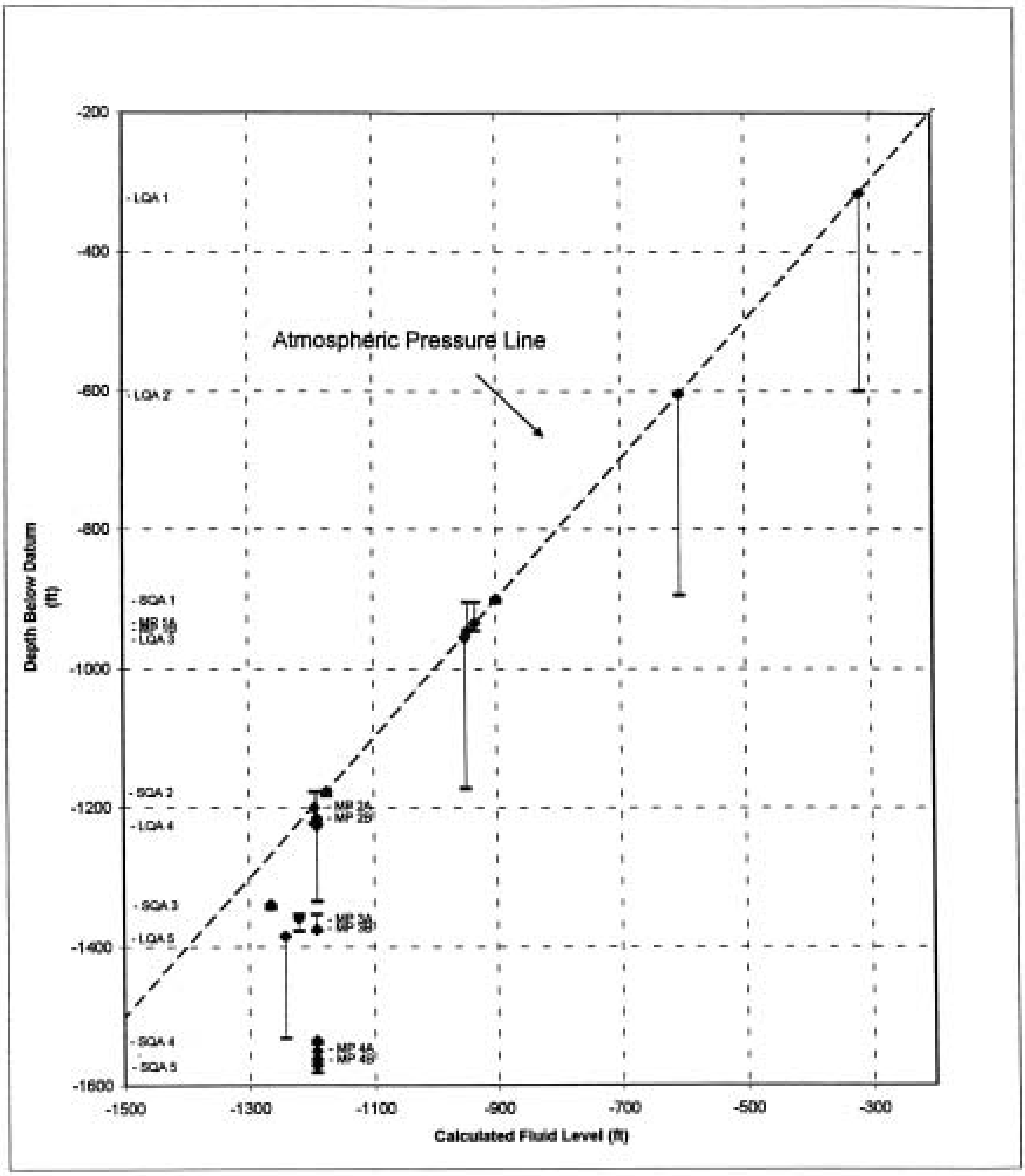
Figure 1 (continued)

TIME DATE	PORT NUMBER	PROBE NUMBER	PRES (psi)	ATMOS (psi)	Rf Pz'D (ft)	TEMP (C)	DEPTH (ft)	MOTOR POSITION
Mon Oct 01 15:25:24 2001	15	1	52.16	11.52	-1442.0	20.4	1535.7	INSIDE (Arm)
Mon Oct 01 15:25:48 2001	15	1	160.12	11.52	-1192.9	20.4	1535.7	OUTSIDE (Shoe)
Mon Oct 01 15:26:36 2001	15	1	52.09	11.52	-1442.1	20.4	1535.7	INSIDE (Arm)
Mon Oct 01 15:32:54 2001	16	1	58.69	11.52	-1441.8	20.6	1550.6	INSIDE (Arm)
Mon Oct 01 15:33:18 2001	16	1	166.56	11.52	-1192.9	20.6	1550.6	OUTSIDE (Shoe)
Mon Oct 01 15:33:39 2001	16	1	58.57	11.52	-1442.1	20.6	1550.6	INSIDE (Arm)
Mon Oct 01 15:36:00 2001	17	1	63.28	11.52	-1442.2	20.6	1561.6	INSIDE (Arm)
Mon Oct 01 15:36:23 2001	17	1	171.26	11.52	-1193.1	20.6	1561.6	OUTSIDE (Shoe)
Mon Oct 01 15:36:39 2001	17	1	63.34	11.52	-1442.1	20.6	1561.6	INSIDE (Arm)
Mon Oct 01 15:38:48 2001	18	1	67.57	11.52	-1442.3	20.7	1571.6	INSIDE (Arm)
Mon Oct 01 15:39:07 2001	18	1	175.60	11.52	-1193.0	20.7	1571.6	OUTSIDE (Shoe)
Mon Oct 01 15:39:25 2001	18	1	67.69	11.52	-1442.0	20.7	1571.6	INSIDE (Arm)
Mon Oct 01 15:59:27 2001	0	1	11.47	11.52	-0.1	18.3	ATMOS	INSIDE (Home)

Figure 2

Piezometric Profile (Post-Inflation)
Monitoring Well:
R-37

Profile Date: 10/08/01
Comments: All Zones
(Post-Inflation)
G.L. Ref. Elev.: Ground



Plot By:________ Date:______
Checked By:__DL__ Date:_21-NOV-01_
Westbay Project : WB777
File: Graph Chart 1

Client: Los Alamos National Lab
Site: LANL
Datum: Ground Level

Figure 2 (continued)

MOSDAX Data Report
(c) WESTBAY INSTRUMENTS 1990-1991
Date Of Report: Mon Oct 22 09:16:21 2001

Company Name: LANL
Project Name: R_37-2 Post-Inflation Profile
Well ID: CdV_R37-2
Well Description: Plastic MP-55
Well Elevation: 0.00 (ft)

Probe Information

Logical Probe-1 - Serial #: 2652 - Description: SAMPLER

Port Information

Port #:00 - Description ATMOSPHERIC - Depth 0.0 (ft) - ACF 1.0
Port #:01 - Description LQA-1 - Depth 315.6 (ft) - ACF 1.0
Port #:02 - Description LQA-2 - Depth 605.3 (ft) - ACF 1.0
Port #:03 - Description SQA-1 - Depth 900.4 (ft) - ACF 1.0
Port #:04 - Description MP-1A - Depth 934.9 (ft) - ACF 1.0
Port #:05 - Description MP-1B - Depth 945.9 (ft) - ACF 1.0
Port #:06 - Description LQA-3 - Depth 955.8 (ft) - ACF 1.0
Port #:07 - Description SQA-2 - Depth 1177.3 (ft) - ACF 1.0
Port #:08 - Description MP-2A - Depth 1200.3 (ft) - ACF 1.0
Port #:09 - Description MP-2B - Depth 1216.2 (ft) - ACF 1.0
Port #:10 - Description LQA-4 - Depth 1226.2 (ft) - ACF 1.0
Port #:11 - Description SQA-3 - Depth 1339.5 (ft) - ACF 1.0
Port #:12 - Description MP-3A - Depth 1359.3 (ft) - ACF 1.0
Port #:13 - Description MP-3B - Depth 1375.2 (ft) - ACF 1.0
Port #:14 - Description LQA-5 - Depth 1385.2 (ft) - ACF 1.0
Port #:15 - Description SQA-4 - Depth 1535.7 (ft) - ACF 1.0
Port #:16 - Description MP-4A - Depth 1550.6 (ft) - ACF 1.0
Port #:17 - Description MP-4B - Depth 1561.6 (ft) - ACF 1.0
Port #:18 - Description SQA-5 - Depth 1571.6 (ft) - ACF 1.0

Figure 2 (continued)

TIME DATE	PORT NUMBER	PROBE NUMBER	PRES (psi)	ATMOS (psi)	RFPZ'D (ft)	TEMP (C)	DEPTH (ft)	MOTOR POSITION
Mon Oct 08 12:30:15 2001	0	1	11.75	11.31	1.0	16.4	ATMOS	INSIDE (Home)
Mon Oct 08 12:43:33 2001	18	1	128.70	11.31	-1300.8	20.4	1571.6	INSIDE (Arm)
Mon Oct 08 12:44:24 2001	18	1	175.63	11.31	-1192.5	20.5	1571.6	OUTSIDE (Shoe)
Mon Oct 08 12:45:17 2001	18	1	128.81	11.31	-1300.6	20.5	1571.6	INSIDE (Arm)
Mon Oct 08 12:55:03 2001	17	1	124.51	11.31	-1300.5	20.7	1561.6	INSIDE (Arm)
Mon Oct 08 12:55:44 2001	17	1	171.20	11.31	-1192.8	20.7	1561.6	OUTSIDE (Shoe)
Mon Oct 08 12:56:16 2001	17	1	124.45	11.31	-1300.6	20.7	1561.6	INSIDE (Arm)
Mon Oct 08 12:58:23 2001	16	1	119.61	11.31	-1300.8	20.7	1550.6	INSIDE (Arm)
Mon Oct 08 12:59:21 2001	16	1	166.55	11.31	-1192.5	20.7	1550.6	OUTSIDE (Shoe)
Mon Oct 08 13:00:23 2001	16	1	119.68	11.31	-1300.6	20.7	1550.6	INSIDE (Arm)
Mon Oct 08 13:11:46 2001	15	1	113.15	11.31	-1300.8	20.7	1535.7	INSIDE (Arm)
Mon Oct 08 13:12:31 2001	15	1	160.08	11.31	-1192.5	20.7	1535.7	OUTSIDE (Shoe)
Mon Oct 08 13:12:54 2001	15	1	113.33	11.31	-1300.4	20.7	1535.7	INSIDE (Arm)
Mon Oct 08 13:18:16 2001	14	1	46.17	11.31	-1304.8	20.5	1385.2	INSIDE (Arm)
Mon Oct 08 13:19:04 2001	14	1	73.38	11.31	-1242.0	20.5	1385.2	OUTSIDE (Shoe)
Mon Oct 08 13:19:29 2001	14	1	46.10	11.31	-1304.9	20.5	1385.2	INSIDE (Arm)
Mon Oct 08 13:23:05 2001	13	1	43.81	11.31	-1300.2	20.5	1375.2	INSIDE (Arm)
Mon Oct 08 13:23:36 2001	13	1	90.80	11.31	-1191.8	20.5	1375.2	OUTSIDE (Shoe)
Mon Oct 08 13:24:30 2001	13	1	43.87	11.31	-1300.1	20.5	1375.2	INSIDE (Arm)
Mon Oct 08 13:27:07 2001	12	1	36.97	11.31	-1300.1	20.5	1359.3	INSIDE (Arm)
Mon Oct 08 13:27:42 2001	12	1	71.51	11.31	-1220.4	20.5	1359.3	OUTSIDE (Shoe)
Mon Oct 08 13:28:05 2001	12	1	36.97	11.31	-1300.1	20.5	1359.3	INSIDE (Arm)
Mon Oct 08 13:32:14 2001	11	1	28.32	11.31	-1300.2	20.5	1339.5	INSIDE (Arm)
Mon Oct 08 13:32:41 2001	11	1	43.50	11.31	-1265.2	20.5	1339.5	OUTSIDE (Shoe)
Mon Oct 08 13:33:04 2001	11	1	28.44	11.31	-1300.0	20.5	1339.5	INSIDE (Arm)
Mon Oct 08 13:37:47 2001	10	1	11.91	11.31	-1224.8	20.4	1226.2	INSIDE (Arm)
Mon Oct 08 13:39:04 2001	10	1	26.50	11.31	-1191.2	20.4	1226.2	OUTSIDE (Shoe)
Mon Oct 08 13:39:41 2001	10	1	11.97	11.31	-1224.7	20.4	1226.2	INSIDE (Arm)
Mon Oct 08 13:42:00 2001	9	1	11.91	11.31	-1214.8	20.4	1216.2	INSIDE (Arm)
Mon Oct 08 13:42:33 2001	9	1	22.20	11.31	-1191.1	20.4	1216.2	OUTSIDE (Shoe)
Mon Oct 08 13:44:58 2001	9	1	11.79	11.31	-1215.1	20.4	1216.2	INSIDE (Arm)
Mon Oct 08 13:50:11 2001	8	1	11.91	11.31	-1198.9	20.3	1200.3	INSIDE (Arm)
Mon Oct 08 13:50:37 2001	8	1	13.73	11.31	-1194.7	20.3	1200.3	OUTSIDE (Shoe)
Mon Oct 08 13:51:00 2001	8	1	11.85	11.31	-1199.1	20.3	1200.3	INSIDE (Arm)
Mon Oct 08 13:53:07 2001	7	1	11.73	11.31	-1176.3	20.3	1177.3	INSIDE (Arm)
Mon Oct 08 13:53:37 2001	7	1	12.15	11.31	-1175.3	20.3	1177.3	OUTSIDE (Shoe)
Mon Oct 08 13:53:57 2001	7	1	11.73	11.31	-1176.3	20.3	1177.3	INSIDE (Arm)
Mon Oct 08 13:59:56 2001	6	1	11.66	11.31	-955.0	20.2	955.8	INSIDE (Arm)
Mon Oct 08 14:00:23 2001	6	1	13.90	11.31	-949.8	20.2	955.8	OUTSIDE (Shoe)
Mon Oct 08 14:01:23 2001	6	1	11.72	11.31	-954.9	20.1	955.8	INSIDE (Arm)
Mon Oct 08 14:02:34 2001	5	1	11.78	11.31	-944.8	20.0	945.9	INSIDE (Arm)
Mon Oct 08 14:03:05 2001	5	1	11.84	11.31	-944.7	20.0	945.9	OUTSIDE (Shoe)
Mon Oct 08 14:03:32 2001	5	1	11.66	11.31	-945.1	20.0	945.9	INSIDE (Arm)

Figure 2 (continued)

TIME DATE	PORT NUMBER	PROBE NUMBER	PRES (psi)	ATMOS (psi)	RΓPzD (ft)	TEMP (C)	DEPTH (ft)	MOTOR POSITION
Mon Oct 08 14:05:20 2001	4	1	11.77	11.31	-933.8	19.9	934.9	INSIDE (Arm)
Mon Oct 08 14:05:46 2001	4	1	11.95	11.31	-933.4	19.8	934.9	OUTSIDE (Shoe)
Mon Oct 08 14:06:04 2001	4	1	11.77	11.31	-933.8	19.8	934.9	INSIDE (Arm)
Mon Oct 08 14:07:35 2001	3	1	11.71	11.31	-899.5	19.7	900.4	INSIDE (Arm)
Mon Oct 08 14:08:06 2001	3	1	12.13	11.31	-898.5	19.7	900.4	OUTSIDE (Shoe)
Mon Oct 08 14:08:27 2001	3	1	11.59	11.31	-899.8	19.7	900.4	INSIDE (Arm)
Mon Oct 08 14:13:36 2001	2	1	11.45	11.31	-605.0	19.2	605.3	INSIDE (Arm)
Mon Oct 08 14:14:06 2001	2	1	11.93	11.31	-603.9	19.2	605.3	OUTSIDE (Shoe)
Mon Oct 08 14:14:22 2001	2	1	11.62	11.31	-604.6	19.1	605.3	INSIDE (Arm)
Mon Oct 08 14:18:49 2001	1	1	11.41	11.31	-315.4	18.3	315.7	INSIDE (Arm)
Mon Oct 08 14:19:17 2001	1	1	11.71	11.31	-314.7	18.2	315.7	OUTSIDE (Shoe)
Mon Oct 08 14:19:39 2001	1	1	11.46	11.31	-315.3	18.1	315.7	INSIDE (Arm)
Mon Oct 08 14:23:25 2001	0	1	11.42	11.31	0.3	17.2	ATMOS	INSIDE (Home)

Summary Casing Log

Company: Los Alamos National Lab
Well: CDV-R-37-2
Site: LANL
Project: Hydrogeology Study

Job No: WB777
Author: GG

Well Information

Reference Datum: Ground Level
Elevation of Datum: 0.00 ft.
MP Casing Top: 0.00 ft.
MP Casing Length: 1582.64 ft.

Borehole Depth: 1587.00 ft.
Borehole Inclination: vertical
Borehole Diameter: 5.00 in.

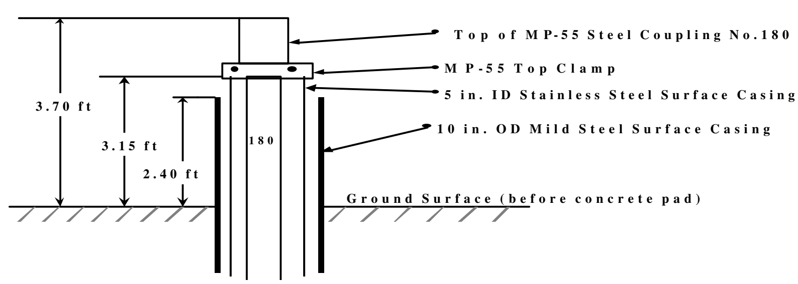
Well Description:
PlasticMP55
Other References:
Pipe-based wire-wrapped screens.
BF and screens after LANL 08/29/01

File Information

File Name: CDVR37_S.WWD
Report Date: Tue Oct 23 13:39:28 2001

File Date: Oct 23 11:51:10 2001

Sketch of Wellhead Completion



MP55 System Casing: CdV_R37-3

Well Designer Report
Los Alamos National Lab

Job No: WB777
Well: CDV-R-37-2

Legend

(Qty) MP Components

(Library - WD Library 7/27/00)

(23)	0601M15 - MP55 Casing, 1.5 m, PVC
(141)	0601M30 - MP55 Casing, 3.0 m, PVC
(14)	0612 - MP55 Packer, Stiffened, SS
(2)	0601M10 - MP55 Casing, 1.0 m, PVC
(1)	0603 - MP55 End Plug
(159)	0602 - MP55 Regular Coupling
(18)	0605 - MP55 Measurement Port
(4)	0607 - MP55 Hydraulic Pumping Port
(7)	0608 - MP55 Magnetic Location Collar

Geology

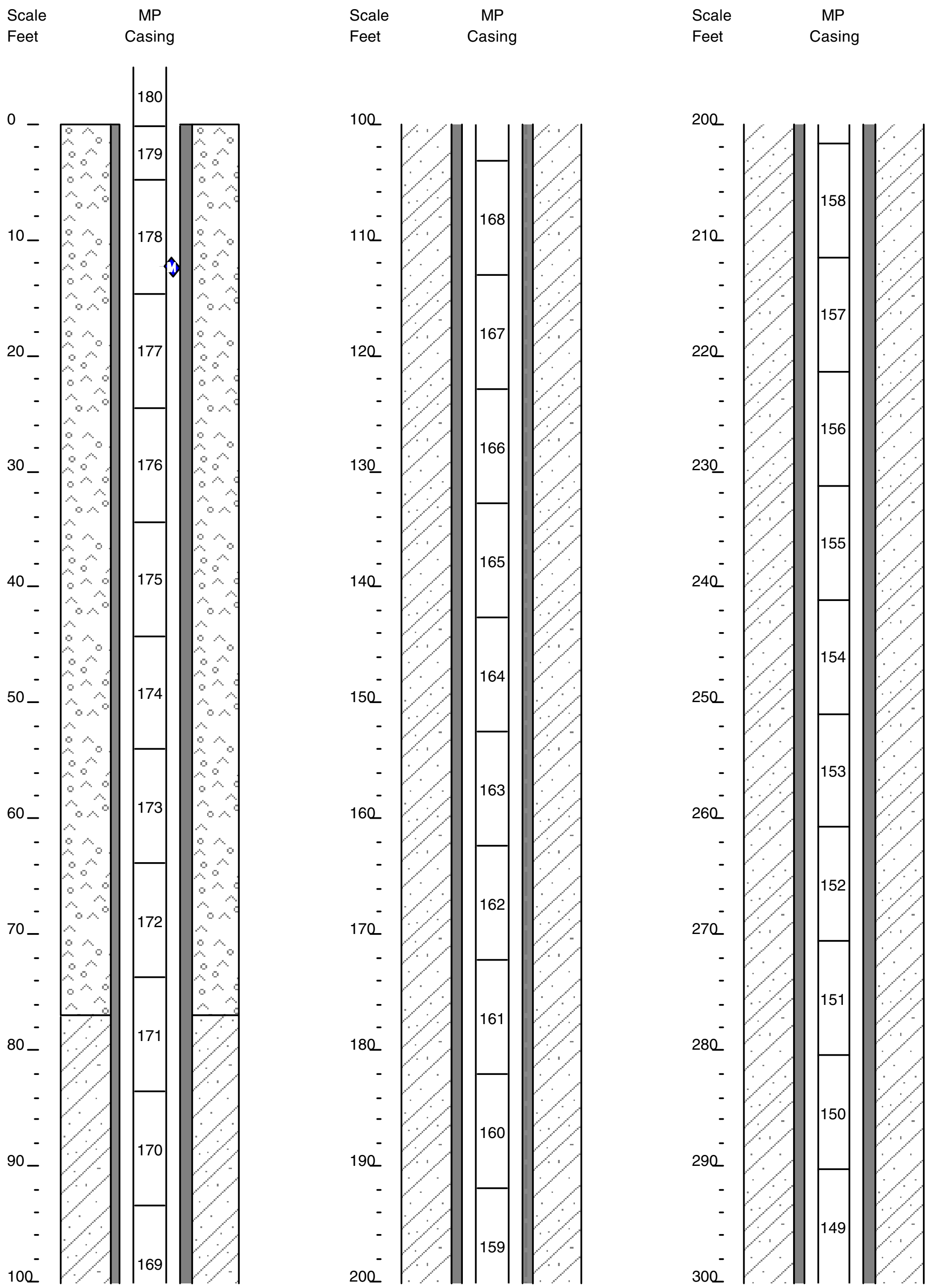
Backfill/Casing

- Concrete
- Bentonite, Sand
- Sand Coarse
- Stainless Steel
- Well Screen

 Tue Oct 23 13:50:14 2001 Page: 2

Summary MP Casing Log
Los Alamos National Lab

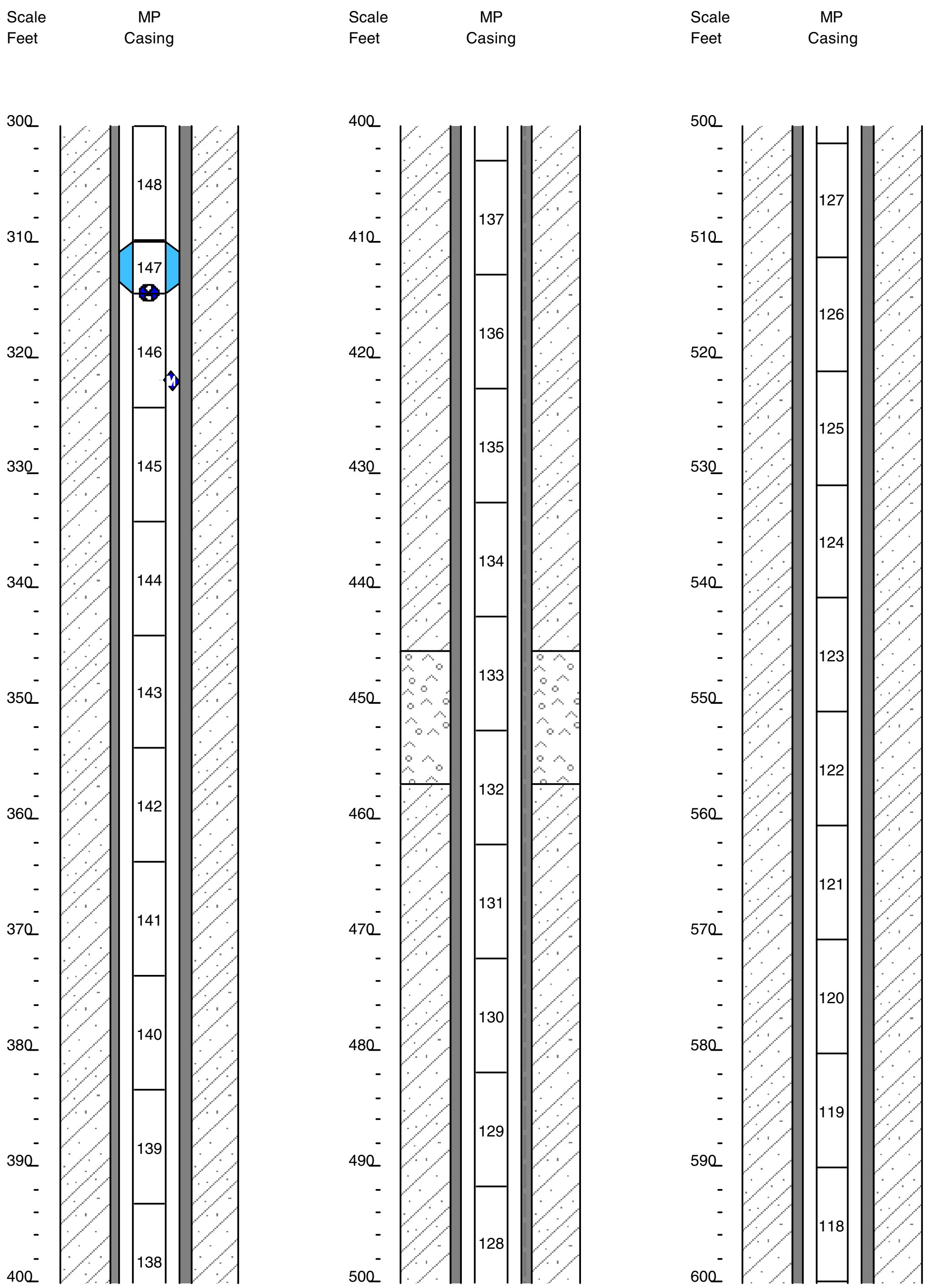
Job No: WB777
Well: CDV-R-37-2



Tue Oct 23 11:51:10 2001
Page: 1

Summary MP Casing Log
Los Alamos National Lab

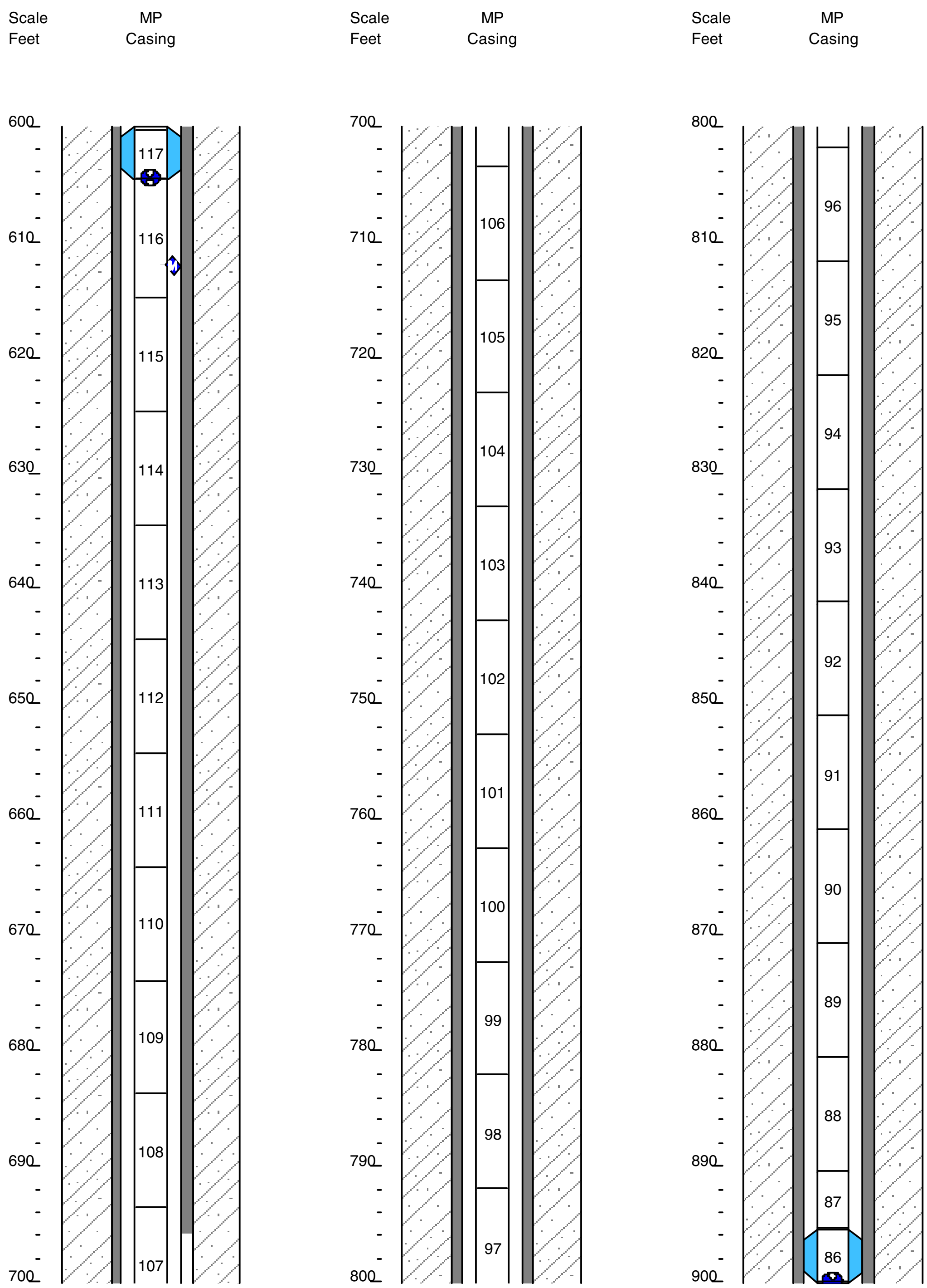
Job No: WB777
Well: CDV-R-37-2



 Tue Oct 23 11:51:11 2001 Page: 2

Summary MP Casing Log
Los Alamos National Lab

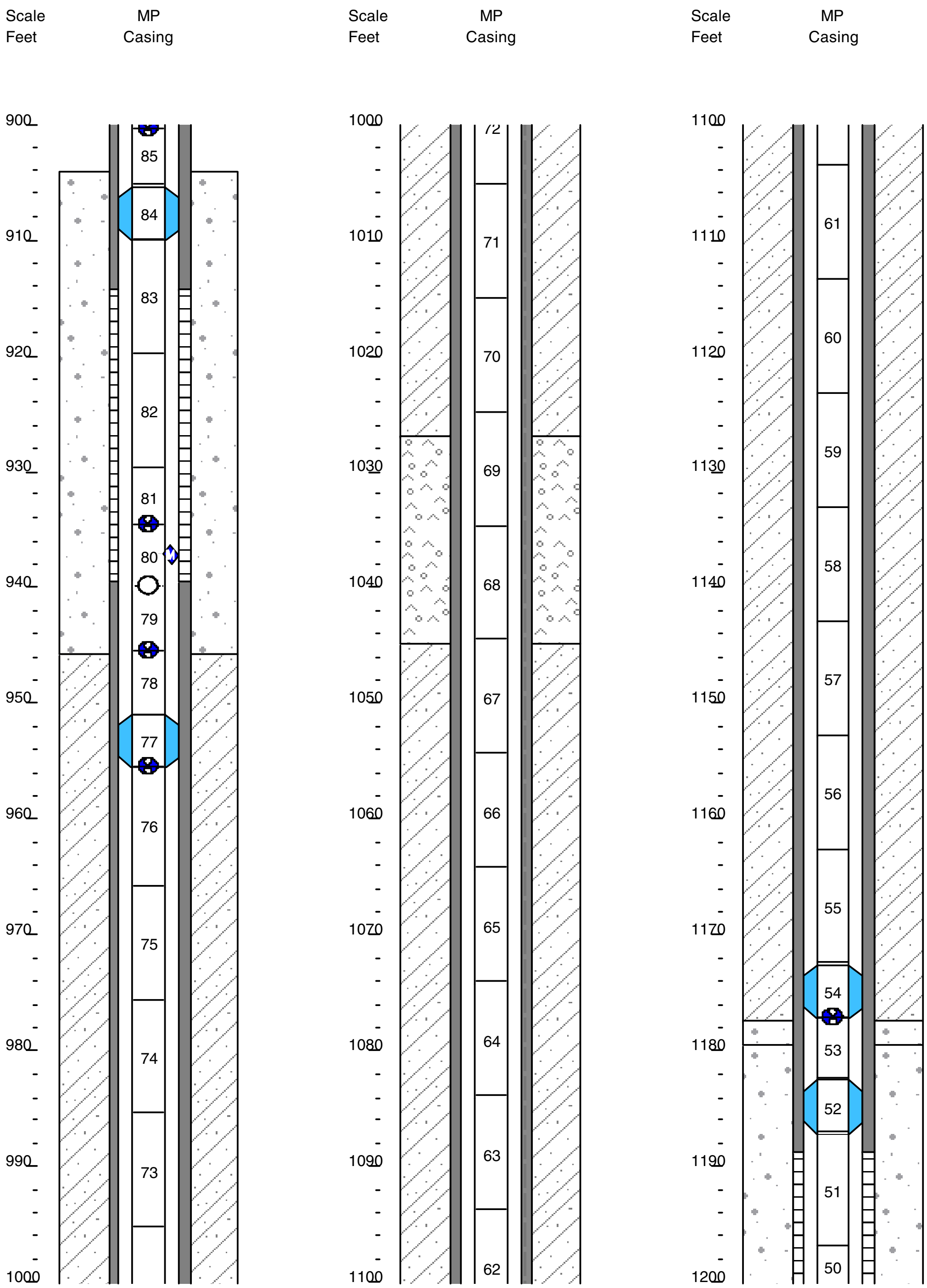
Job No: WB777
Well: CDV-R-37-2



 Tue Oct 23 11:51:11 2001 Page: 3

Summary MP Casing Log
Los Alamos National Lab

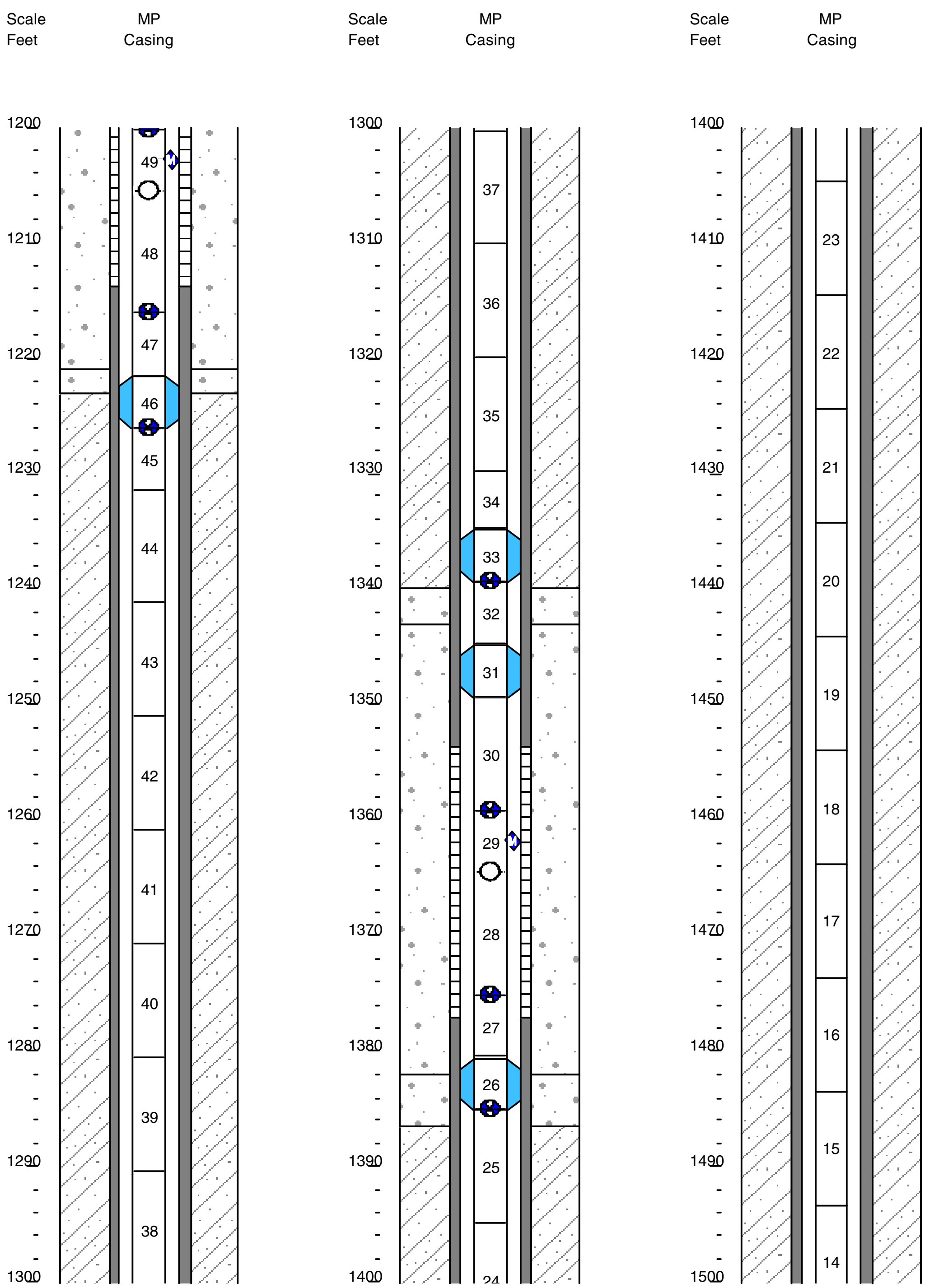
Job No: WB777
Well: CDV-R-37-2



 Tue Oct 23 11:51:12 2001 Page: 4

Summary MP Casing Log
Los Alamos National Lab

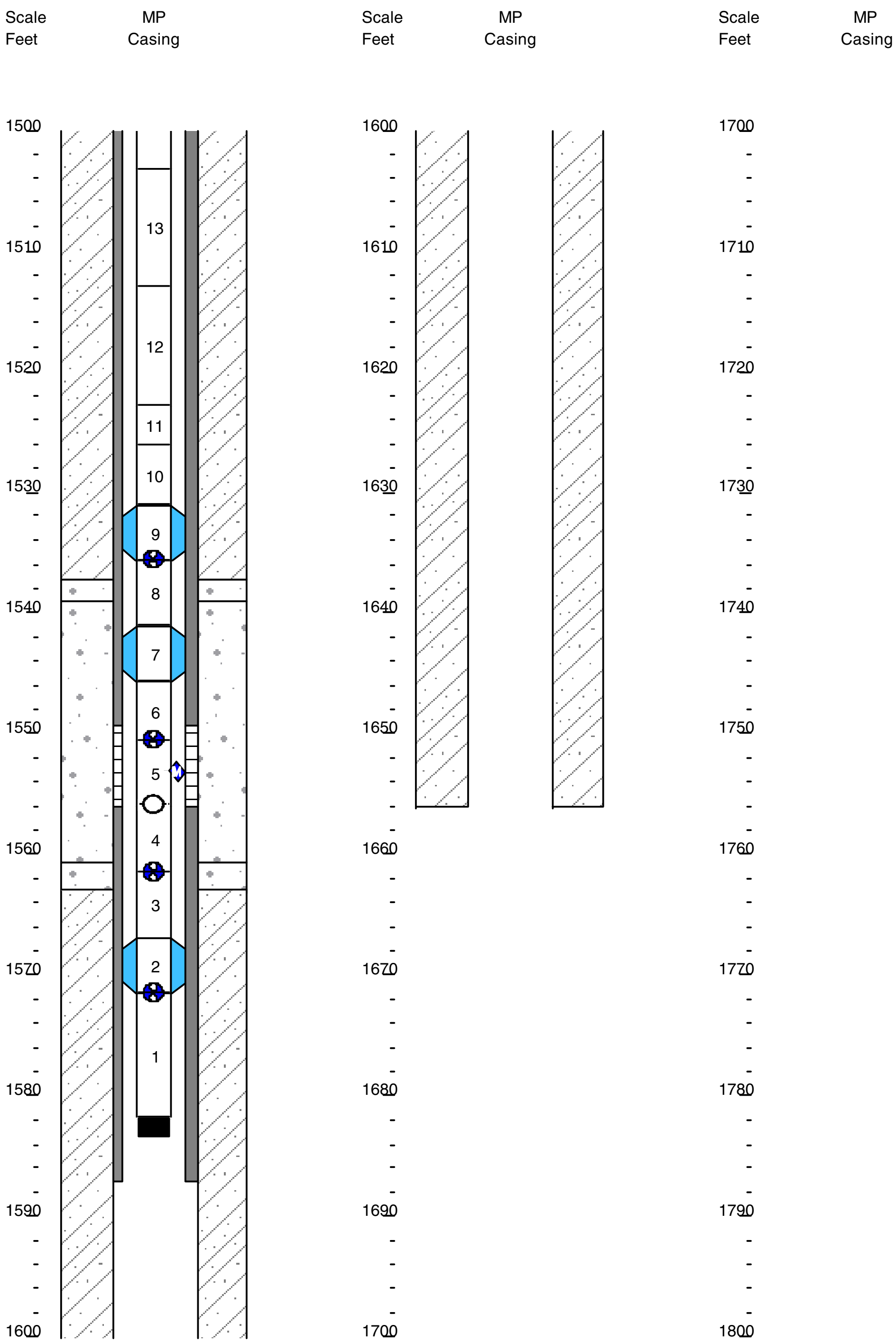
Job No: WB777
Well: CDV-R-37-2



 Tue Oct 23 11:51:13 2001 Page: 5

Summary MP Casing Log
Los Alamos National Lab

Job No: WB777
Well: CDV-R-37-2



(c) Westbay Instruments Inc. 2000 Tue Oct 23 11:51:14 2001 Page: 6

Appendix E

Thin-Section Descriptions of
Geologic Samples from CdV-R-37-2

CdV-R-37-2, 5–10 ft *Hand-picked fragments*	This polished thin section contains tuff with abundant phenocryst clots. The clots consist of sanidine, plagioclase, clinopyroxene, and minor iron-titanium oxides and biotite. Phenocryst clots are embedded in pumiceous glass. The glass varies from clear to pinkish-gray in thin section. No resorption features are observed in the phenocryst aggregates. Apart from these phenocryst clots within pumice, the tuff matrix is sparsely porphyritic with sanidine, quartz, clinopyroxene, and minor iron-titanium oxides. Brownish alteration products occur within the glassy matrix and along fractures in feldspar grains. Together, the tuff clasts and mineral clots consist of approximately 28% glass, 37% sanidine, 10% plagioclase, 14% clinopyroxene, 6% quartz, and 3% each of iron-titanium oxides and biotite.
CdV-R-37-2, 907–912 ft *Hand-picked fragments*	This polished thin section contains multiple dacite lithologies. Porphyritic dacites with abundant glomerophyric plagioclase and pyroxene in a trachytic texture predominate (75%). Aphyric to microporphyritic dacites with altered fine-grained acicular minerals (orthopyroxene?) in a devitrified matrix represent 19% of the clasts. Porphyritic dacites with altered and reacted coarse biotite grains and abundant zoned plagioclase, embedded in a devitrified matrix, represent 6% of the clasts.
CdV-R-37-2, 967–972 ft *Hand-picked fragments*	This polished thin section contains multiple clasts of porphyritic dacite with abundant plagioclase and pyroxene (82%), microporphyritic and aphyric clasts (13%), and granular-matrix dacite fragments (3%). Glomerophyric phenocryst aggregates and trachytic texture in devitrified and partially altered matrix are common to all the dacite types present. A few single grains of iron-titanium oxides are also present (2%).
CdV-R-37-2, 1062-–1067 ft, SS *Hand-picked fragments*	This polished thin section consists of poorly sorted and massive crystal-rich sandstone. It contains abundant subrounded quartz and plagioclase crystals with pyroxene, amphibole, biotite, muscovite, microcline, and iron-titanium oxides embedded in a clayey matrix (94%). The sandstone contains some altered dacite clasts (6%). The altered dacite fragments are porphyritic with abundant plagioclase and minor amounts of pyroxene embedded in a matrix with trachytic texture.
CdV-R-37-2, 1062–1067 ft dac *Hand-picked fragments*	This polished thin section contains monolithologic porphyritic dacite clasts with abundant plagioclase, hornblende, and pyroxene, and minor iron-titanium oxides. Hornblende grains (60 µm to 0.1 mm) are equidimensional or elongate prismatic, moderately altered with opaque haloes around the edges. Clinopyroxene phenocrysts (≤60 µm) are light brownish-gray with faint pleochroism, fractured, and less altered than hornblende. Orthopyroxene phenocrysts are elongate prismatic, non-pleochroic, and unaltered. Plagioclase is the dominant phenocryst (>65% of phenocrysts); hornblende and pyroxene phenocrysts are ~15% each. The matrix is devitrified and contains abundant microlites with flow orientation.
CdV-R-37-2, 1072–1077 ft *Hand-picked fragments*	This polished thin section contains monolithologic porphyritic dacite clasts, with phenocrysts of strongly zoned plagioclase (60% of phenocrysts), subequal pyroxene and hornblende (~19% of phenocrysts each), and a few resorbed quartz phenocrysts and iron-titanium oxides embedded in a moderately altered matrix. Hornblende grains are equidimensional to elongate prismatic, ranging in size from 54 to 89 µm. Hornblende phenocrysts are mostly altered; some have been replaced by pyroxene and iron-titanium oxides. The pyroxene grains (50 µm–1 mm) are less altered than hornblende; some clinopyroxene phenocrysts have sieved texture.
CdV-R-37-2, 1187–1192 ft *Hand-picked fragments*	This polished thin section contains monolithologic porphyritic dacite clasts with coarse plagioclase (136 µm–0.17 mm), partially altered pyroxene, and extensively altered hornblende embedded in a matrix with abundant microlites. Aggregates of resorbed plagioclase with mesh texture represent about 64% percent of the phenocryst content. Clinopyroxene grains exhibit faint pleochroism of pinkish brown to light brown green. Almost all pyroxene grains are moderately altered and contain alteration halos. Hornblende grains are elongate prismatic and mostly altered to opaque pseudomorphs, except for remnant patches in the cores of the grains. There are more hornblende grains (36% of phenocrysts) than pyroxene (22% of phenocrysts). The matrix is mildly devitrified and contains abundant microlites with preferred orientation. A few heavily altered, medium-grained acicular mafic minerals (orthopyroxene?) are also present in the matrix.

CdV-R-37-2, 1207–1209 ft, SS *Hand-picked fragments*	This polished thin section consists of fine-grained sandstone (siltstone). It is crystal-rich with subequal amounts of plagioclase and quartz, and a few grains of hornblende, clinopyroxene, biotite, muscovite, and microcline embedded in a clayey matrix. The crystalline detritus is angular to subrounded, and poorly sorted. Dacite clasts with plagioclase, hornblende, and pyroxene phenocrysts are present. One of the larger of these clasts contains about 58% plagioclase, 24% hornblende, and 17% pyroxene within a microlite-dominated altered matrix of trachytic texture. Banded clay rinds surround the dacite clasts, and deformed spheroid forms in the groundmass indicate clay-cemented ooids.
CdV-R-37-2, 1207–1209 ft, lava *Hand-picked fragments*	This polished thin section contains monolithologic porphyritic dacite fragments with coarse plagioclase, pyroxene, and altered hornblende phenocrysts. Glomerophyric textures are common. Plagioclase grains represent about 50% of the phenocrysts and are strongly zoned, fractured, and partially resorbed. The plagioclase phenocrysts range in size from 75 to 150 µm. Pyroxene phenocrysts are fractured, moderately altered, and represent about 27% of the phenocrysts. Hornblende grains (22% of the phenocrysts) are mostly altered to opaque pseudomorphs. The matrix contains abundant microlites.
CdV-R-37-2, 1389–1394 ft *Hand-picked fragments*	This polished thin section contains monolithologic porphyritic dacite fragments with plagioclase, pyroxene, hornblende, and minor iron-titanium oxide phenocrysts. The plagioclase grains are strongly zoned, partially resorbed, and fractured. The phenocrysts are glomerophyric. Hornblende grains are mostly altered; pyroxene grains are fractured but exhibit minor alteration. The iron-titanium oxides are euhedral and medium-grained. The matrix shows minimal devitrification, appears glassy, and contains abundant microlites with trachytic texture.
CdV-R-37-2, 1479–1494 ft *Hand-picked fragments*	This polished thin section contains monolithologic porphyritic dacite fragments with plagioclase (42% of phenocrysts), pyroxene (37% of phenocrysts), and hornblende (21% of phenocrysts). Phenocryst contents are estimated from one of the larger clasts. Plagioclase grains are coarse, strongly zoned, and show minor resorption. The pyroxene grains are fractured, have alteration rinds, and are of variable size (≤90 µm). As in most other samples of these lavas, hornblende grains are mostly altered to opaque pseudomorphs, with some remnant fresh patches. The matrix appears glassy and is dominated by microlites with preferred orientation.
CdV-R-37-2, 1514–1519 ft *Hand-picked fragments*	This polished thin section contains monolithologic porphyritic dacite fragments with phenocrysts of plagioclase, pyroxene, hornblende, and minor iron-titanium oxides embedded in a glassy matrix loaded with microlites with preferred orientation. Plagioclase grains are most abundant (55% of phenocrysts), strongly zoned, mildly resorbed, fractured, and slightly altered. Light-brown glassy inclusions are common in the sieved outer rims of the feldspars. Pyroxene grains (24% of phenocrysts) are variable in size (15–75 µm), mostly fractured, and partially altered. Hornblende grains (21% of phenocrysts) are mostly altered into opaque masses and partially replaced by clinopyroxene. The matrix is partially devitrified.
CdV-R-37-2, 1654–1659 ft *Hand-picked fragments*	This polished thin section contains monolithologic porphyritic dacite fragments with plagioclase, pyroxene, hornblende, and minor iron-titanium oxides and biotite in a partially devitrified matrix with abundant microlites. The phenocrysts form glomerophyric clots. The plagioclase grains are variable in size (35–240 µm), partially resorbed, and strongly zoned. Pyroxene grains (15–140 µm) are highly fractured, with alteration mostly confined to cracks. Some clinopyroxene aggregates appear to have formed from hornblende alteration. Hornblende grains are coarse (35–190 µm) and altered, resulting in opaque psedomorphs. Pyroxene and iron-titanium oxides replace some hornblende grains. Phenocrysts occur in relative abundances of 63% (plagioclase), 20% (hornblende), and 16% (pyroxene).

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